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Sky and TELESCOPE

In This Issue:

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Sunset on the moon

SKY and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

Vol. XVIII, No. 9 JULY, 1959

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COVER: The southwestern part of the moon, about two days after full, photographed by Jack Eastman, of Manhattan Beach, California, on April 6, 1958, at 7:30 Universal time. He used a 12½-inch reflector with eyepiece projection, exposure ½ second. The four great craters forming a chain along the terminator are, from bottom to top, Langrenus, 82 miles in diameter; Vendelinus, 94; Petavius, 110; and Furnerius, 81 miles. At the lower right, the relatively smooth, gray plain is a portion of Mare Foecunditatis. (See page 510.)

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Occultation of Regulus by Venus This Month

AN unprecedented opportunity to learn more about the atmosphere of Venus will occur on July 7th, when the planet is to pass in front of the 1st-magnitude star Regulus.

As told on page 474 last month, the phenomenon will be visible in the United States only from the Atlantic seaboard, in full daylight. At Washington, D. C., for example, the star will vanish at the planet's dark edge at 10:15 a.m., Eastern daylight time, and reappear from behind the bright limb 12 minutes later.

Because of the atmosphere of Venus, the star will require roughly 10 seconds to fade from full brightness to invisibility. This dimming is due not to absorption of light, but to dilution; the initially parallel rays of starlight grazingly traversing Venus' atmosphere will be diverged by differential refraction. Accurate photometric observations of the fading should tell astronomers much about the structure of the planet's atmosphere, and give its average molecular weight.

To make such observations, Harvard Observatory is sending teams with special equipment to seven different stations in Europe and the Near East, where Venus will be high in the sky during the occultation. Some of the personnel will be from the Smithsonian Astrophysical Observatory. The expeditions are being sponsored by the U. S. Air Force Cambridge Research Center and the Boeing Aircraft Co.

All of the stations are established observatories: Péridier Observatory, at Le Houga, France; Madrid, Spain; Merate, Asiago, and Catania, in Italy; the Vatican Observatory, at Castel Gandolfo, Vatican City; and the American University Observatory, Beirut, Lebanon. In addition, the Boyden Observatory in South Africa and the Uttar Pradesh State Observatory in India are co-operating. The largest telescopes participating are the Boyden 60-inch reflector and the 48- and 40-inch reflectors at Asiago and Merate, respectively.

There are three kinds of observations planned. Photoelectric light curves of the star will be obtained with fast recorders. For this program, a narrow-band transmission filter will be used to minimize the scattered light of Venus. The second program will be motion-picture photography in red and blue light, on calibrated films, from which the brightness of Regulus can be measured. Third, micrometer measurements of the relative co-ordinates of star and planet are planned, to determine for each station the precise points along the edge of Venus where Regulus vanishes and reappears.

(Continued on page 507)

Observations of Mars in 1958

GERARD DE VAUCOULEURS, *Harvard College Observatory*

THE SPACE AGE has brought about a tremendous increase of popular and governmental interest in the long-neglected field of planetary physical studies. The nearest planets, Venus and Mars, will be the principal objectives of the space-exploration program once our immediate curiosity about the moon is satisfied. In fact, many space probes instrumented for the circumnavigation and atmospheric exploration of both planets have already been proposed.

Intelligent planning must be guided by the best possible background information already available. Also, there is a good deal that remains to be gleaned by both continued patient observation through earth-bound instruments and by application of new observing techniques.

A project for the study of planetary atmospheres was initiated last year at Harvard Observatory by the director, Donald H. Menzel, with the support of the Air Force Cambridge Research Center. Under this project I spent October and November, 1958, at Lowell Observatory in Flagstaff, Arizona, to observe the planet Mars near opposition. Generous time was made available by E. C. Slipher at the 24-inch refractor and by H. L. Johnson at the 21-inch reflector.

Part of my program consisted of photoelectric measurements of the integrated brightness and color of Mars with the 21-inch telescope, in five wave-length regions at 3300, 3600, 4550, 5550, and 6900 angstroms, the first of these through a silver filter. In addition, direct visual studies were made of Martian surface and atmospheric details with the 24-inch instrument. These observations were supplemented by step estimates of surface brightnesses, following the methods described in my book *Physics of the Planet Mars*, in three colors: red (Wratten 25 filter), white-yellow (no filter), and green (Wratten 58). Also, I timed the transits of well-defined surface markings across the central meridian, near the date of opposition.[1] While a complete reduction and evaluation of the observations will require many months, some preliminary results are given in this article.

This photograph of Mars was taken by R. B. Leighton on August 23, 1956, with the Mount Wilson Observatory 60-inch reflector stopped down to 20 inches. It shows the same regions as drawings 3, 10, 13, 15, and 21 (pages 486 and 487), which were made in 1958. Note especially the new dark region near longitude 250°, latitude +25°; compare with the view of October 6, 1941 (page 488), and with page 23 of the November, 1958, issue.

The photoelectric measurements were prompted by a letter from A. Boggess, III, of the Naval Research Laboratory, stating that the brightness of Mars at 2740 angstroms, as measured from a rocket in 1957, gave an unexpectedly high value for the planet's albedo.[2] The main results of the Flagstaff observations appear in the accompanying table and in the figure.

The 1958 magnitude values agree very closely with the mean results of the photographic spectrophotometry of R. v. d. R. Woolley and his colleagues at Mount Stromlo Observatory in 1952 and 1954,[3] and with the photoelectric photometry of Johnson and A. J. Gardiner at Flagstaff in 1954.[4] The Mount Stromlo magnitudes are here corrected by +0.10 magnitude to reduce them to the zero point of the UBV standard system. As determined at the Lick Observatory by J. Stebbins and G. E. Kron, the visual mag-

MONOCHROMATIC MAGNITUDES AND ALBEDOS OF MARS

	Wave Length in Angstroms				
	3300	*3600*	*4550*	*5550*	*6900*
μ	0.0185?	0.0185	0.0185	0.015	0.0115
m	+0.39	+0.49	−0.24	−1.56	−2.50
Δ	26.49	26.49	25.86	25.17	24.70
p	0.049	0.049	0.087	0.165	0.253
A	0.046	0.046	0.082	0.181	0.327

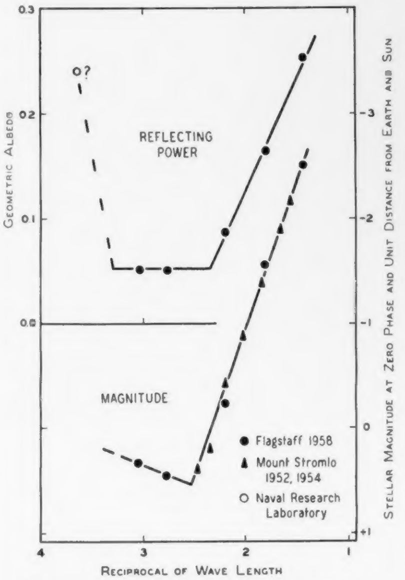
This table gives, for each of the five wave lengths, the following data in successive rows: the phase coefficient, μ, in magnitudes per degree change in phase angle; the magnitude m of Mars, reduced to one astronomical unit distance from the earth and from the sun, and reduced to full phase; the difference Δ between the magnitudes of Mars and the sun; the geometrical albedo p; and the spherical (Russell-Bond) albedo A.

By definition, $\log p = 0.4\Delta - 2 \log \sin s$, where $s = 4''.70$ is the apparent semidiameter of Mars at one astronomical unit distance. Also, $A = pq$, where the phase integral q is given by H. N. Russell's formula: $\log q = 0.342 - 20\mu$.

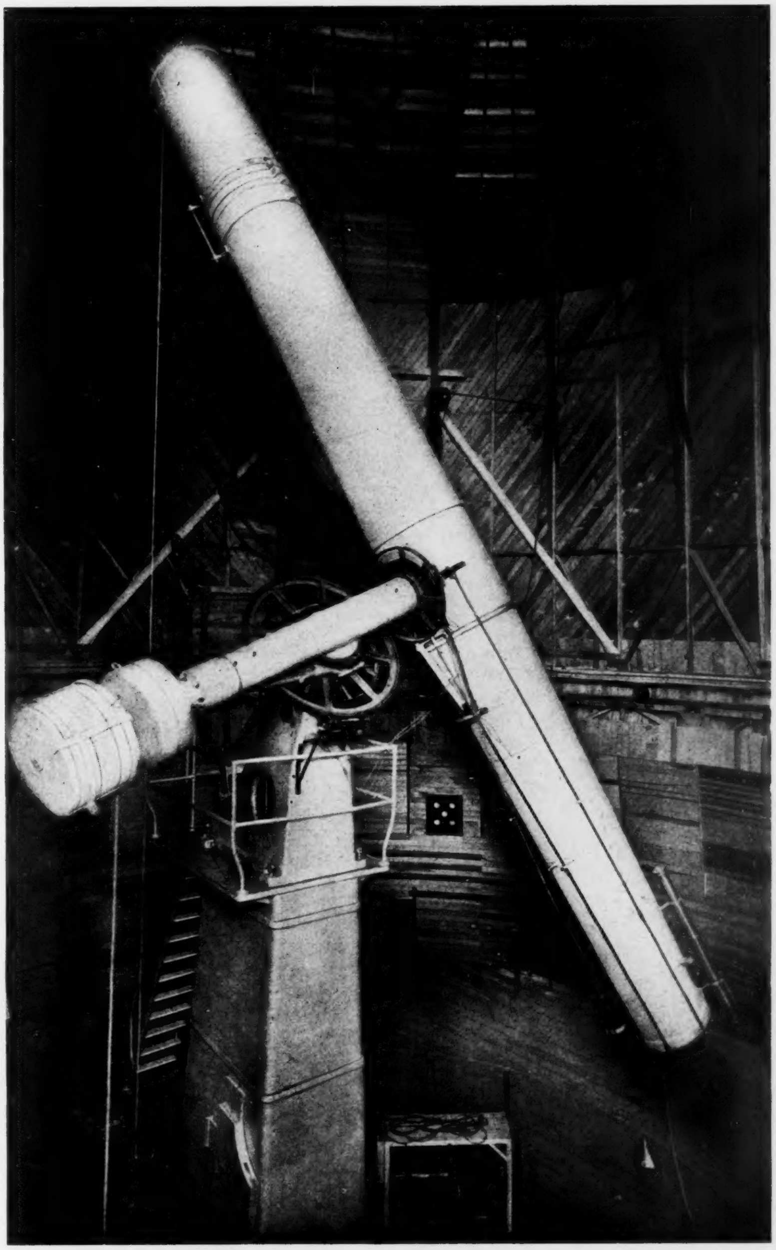
nitude of the sun adopted to compute the albedo is -26.73 ± 0.03,[5] and the values at the other wave lengths are derived from the measured colors of four comparison stars of the same average spectral type, G2V, as the sun. Phase coefficients are interpolated from the Mount Stromlo work; in the ultraviolet a constant value was assumed shortward of 4000 angstroms.

The individual magnitudes reduced to zero phase (exact opposition) show a significant dependence on the longitude of the central meridian. Mars was brighter and redder near central longitudes 100°-120° than near 150°-160°, then brighter again (but not redder) at 180°-200°, and fainter near 240°-270°. This variation correlates reasonably well with the distribution of markings on the surface. Further, at any given longitude, in yellow and red light Mars was intrinsically brighter by about 0.1 magnitude at a mean phase of eight degrees in November than at a phase angle of 21 degrees in October. This change may have something to do with the so-called "blue clearing" of the atmosphere near opposition, first observed by E. C. Slipher in 1937,[6] but more observations will be needed to establish whether this coincidence is significant.

However, the main point of interest is the value of the albedo, 0.046, at 3300 angstroms, which is about the same as at 3600 and 4000. Thus, while Mars is "red" in the visible spectrum, it is "gray" in the ultraviolet, at least between 4000 and 3300. The low ultraviolet albedo is



Stellar magnitude and geometric albedo of Mars in the range 3300 to 6900 angstroms, as determined at Flagstaff in 1958. The earlier Mount Stromlo results are in close agreement. The open circle is a Naval Research Laboratory rocket observation at 2740 angstroms. The horizontal scale is the reciprocal of the wave length in microns.

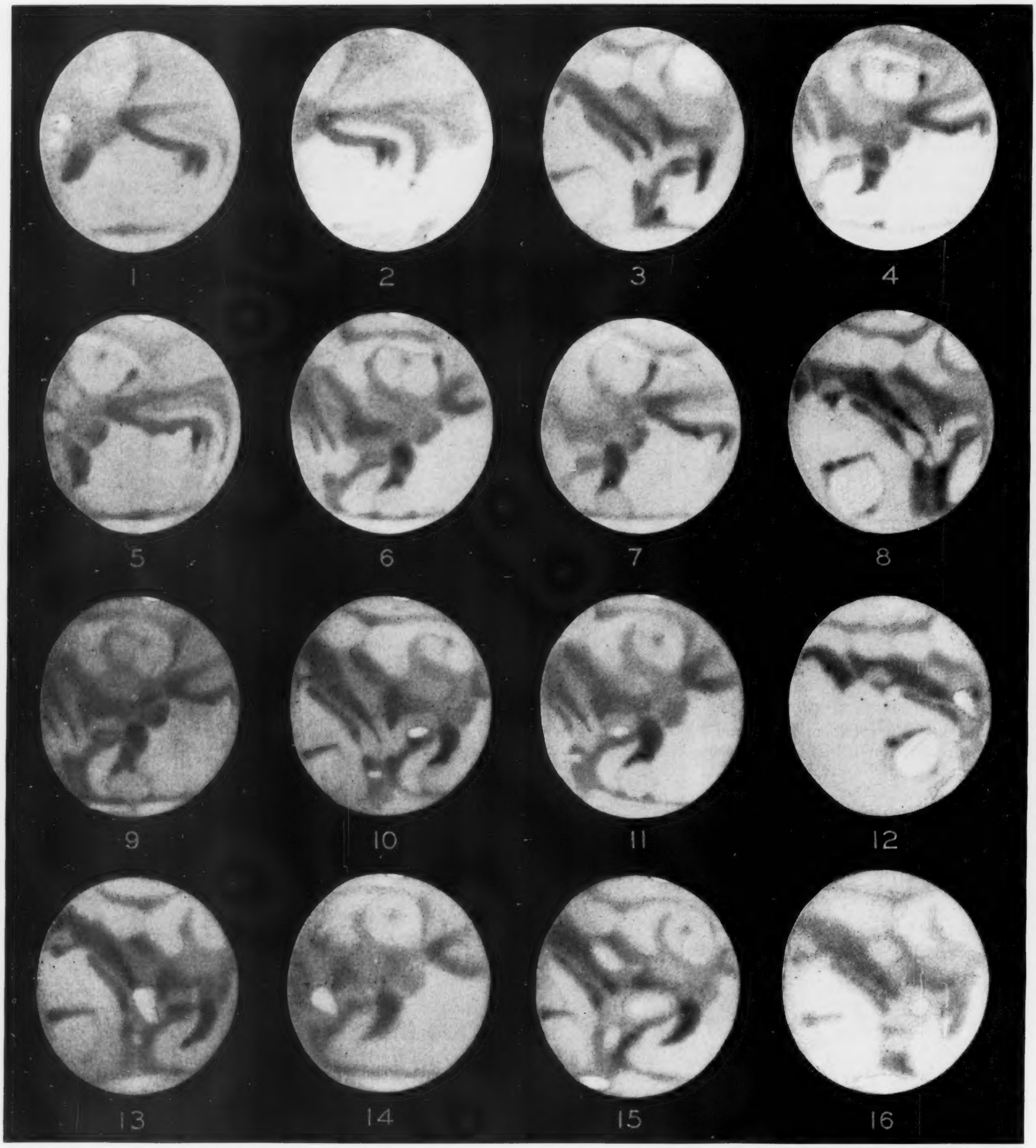


Lowell Observatory's 24-inch refractor was used by the author for the drawings reproduced on the next two pages. This excellent instrument was built by Alvan Clark, and is famous for the more than 60 years of planetary observations made with it by Percival Lowell, the Slipher brothers, and others. The dome for this telescope is actually a cylinder, made of wood, a very suitable material in the dry climate of Arizona.

rather strange for a planet surrounded by a relatively dense and hazy atmosphere, and brings to mind the carbon-smoke hypothesis advanced in 1953 by B. Rosen of the Institut d'Astrophysique, Liege, Belgium.[7] If the albedo is really high at 2740 angstroms, all the increase must occur shortwards of 3100, the effective combined transmission limit of the earth's atmosphere and the silver filter.

On the following pages are sketches made with the 24-inch refractor, reproduced directly from the observing book. The aperture of the objective iris diaphragm was usually 18 or 21 inches, the magnification 310x, or 550x when seeing permitted. Seeing was not particularly good in Flagstaff, especially in November, when several early winter storms were accompanied and followed by excessive atmospheric turbulence. Out of 33 viewing sessions, seeing was rated "very good" but once, "good" eight times, "fair" 17, "poor" six, and "very poor" once. No useful observations could be made on 12 other occasions when it was "poor," "very poor," or "hopeless."

During the interval covered by the ob-



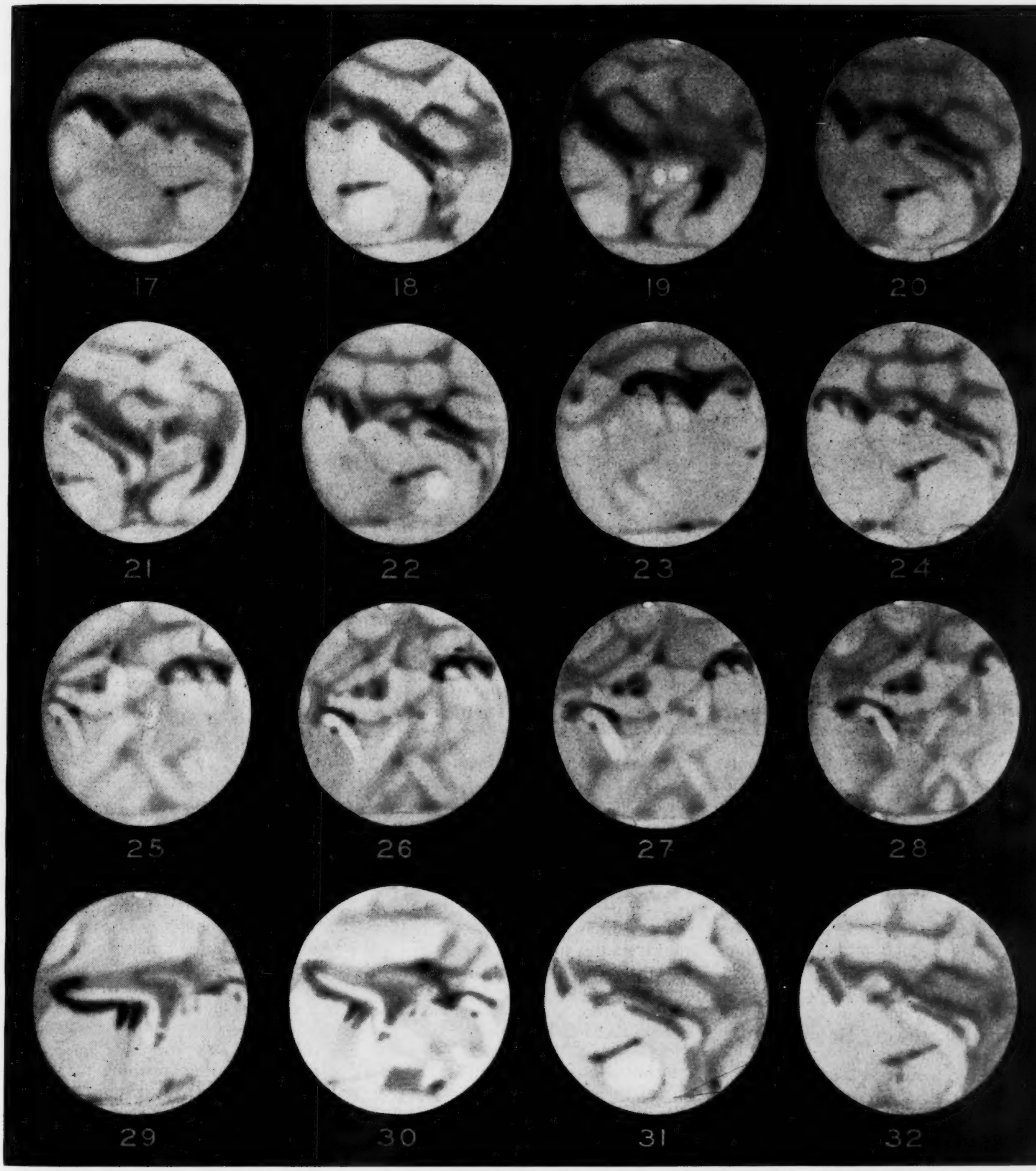
Mars between October 4 and 17, 1958, drawn by G. de Vaucouleurs with Lowell Observatory's 24-inch refractor.

No.	*Oct.*	*UT*	*Power*	*S*	*C.M.*
1	4	7:46	350	3	316°
2	4	10:14	350	3	352°
3	11	6:58	310	3	240°
4	11	10:12	550	2	288°
5	11	12:28	550	2	320°
6	12	9:48	550	3	272°
7	12	11:48	550	2	302°
8	13	6:48	550	2	220°
9	13	10:49	550	2	278°
10	14	9:13	550	3	246°
11	14	11:03	550	3	272°
12	15	6:15	310, 550	3	194°
13	15	9:13	310	3	237°
14	15	12:48	310	4	289°

No.	*Oct.*	*UT*	*Power*	*S*	*C.M.*
15	16	10:53	310	3	252°
16	17	9:53	310	5	228°
17	18	7:33	310	4	186°
18	18	9:58	550	3	220°
19	18	12:08	310	4	252°
20	19	9:28	310, 550	3	204°
21	19	12:03	310, 550	4	242°
22	20	9:28	310	4	195°
23	22	6:53	310	3	140°
24	22	10:28	310	3	192°
25	23	5:24	310, 550	2	109°
26	24	5:28	310, 550	2	101°
27	26	6:13	310	3	94°
28	27	6:03	310	3	82°

No.	*Nov.*	*UT*	*Power*	*S*	*C.M.*
29	4	5:35	310	3	5°
30	7	8:23	310	3	20°
31	22	6:48	310, 550	3	224°
32	23	6:28	310, 550	3	210°

For these drawings, the 24-inch Lowell refractor was generally stopped down to 18 or 21 inches. In each case, Mars was viewed without a filter and then (except for 1, 2, 28, and 31) with a Wratten 21 filter. In addition, a Wratten 25 was used in making drawings 1, 2, 8, 9, and 13. *S* is the seeing, on a scale of 1 = excellent to 5 = very poor. The Martian longitude of the central meridian of the disk is listed under *C.M.*



More drawings of Mars by G. de Vaucouleurs, showing the planet from October 18 to November 23, 1958.

servations, the apparent diameter of Mars' disk was between 16.2 and 19.2 seconds of arc, the Martian latitude of the disk's center between $-8°.4$ and $-14°.8$, and the heliocentric longitude changed from 29° to 57°. Mars was closest to the earth on November 8th, opposition occurring on the 16th. It was midsummer in the southern hemisphere and the south polar cap was very small, on the average nine Martian degrees, or 340 miles, across. This was almost the same diameter observed during the corresponding opposition of 1941 at the same season. Because of its eccentric location, seven degrees from the pole toward Martian longitude 30°, the polar cap was frequently difficult to see or invisible whenever the central meridian was within 60 degrees of longitude 210°.

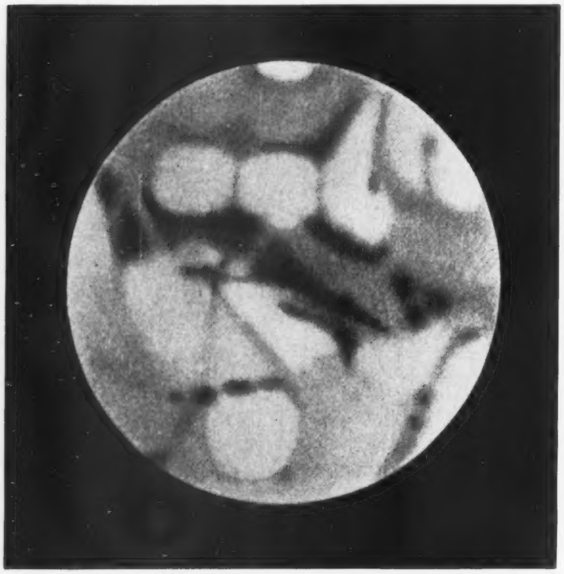
Of the many surface features noted during the observations, there were three of special interest. The new dark area (described by T. Saheki[8]) that developed during the past decade around longitude 250°, latitude +25°, over Amenthes,* is still visible, large, and occasionally very dark when not veiled. See, for example, sketches **8** to **21** of October 12th to 19th, and **31-32** of November 22nd and 23rd. Its southeast spot, called Nodus Laocoontis on some maps, near 247°, +22°, is connected by a prominent curved "canal" to the northwest tip of Mare Cimmerium (Tritonis Sinus).

On one occasion when the seeing was

*For the identification of this and other surface features of Mars, see the maps on page 23 of Sky and Telescope for November, 1958.

good, a small dark knot or "oasis" was observed at the canal's elbow which was connected by a fainter branch to the Nubis Lacus area (8). This curved canal, which I had never seen before, is an objective feature of the Martian surface, whatever its fine structure may be; it shows on photographs taken in 1954 and 1956 at several observatories, but its intensity must have been greater in 1958.

15 degrees west of Phoenicis Lacus, near 130°, −5°. I had observed it at exactly the same place and with the same appearance on September 11 and 12, 1941, but because it did not appear on any map, I thought then that it was a temporary cloud formation. Its reobservation in 1958, 17 years later, and its distinctly pink or cream color indicate that it is permanent, or semipermanent.



Right: A detailed drawing of the desert region of Mars between longitudes 100° and 180°. Included here are Memnonia, Amazonis, and Arcadia, with Mare Sirenum at the top. Note the "new" dark oasis near the tip of Sirenum Sinus; compare with drawings 23 to 28.

Left: Mars as drawn by the author on October 6, 1941, at 21:45 Universal time, with the 8-inch refractor of Peridier Observatory, Le Houga, France. Compare this view with the photograph on page 484 and with drawings 8, 16, 18, 31, and 32.

Another fainter canal was frequently glimpsed between Nodus Laocoontis and the northwest tip of the dark appendage of Mare Cimmerium, near 240°, +10°, but I am not satisfied that it is real. Its appearance had a subjective quality and it could not be held steadily as the other. Although drawn in 1956 by Japanese observers who called it Serpentinus, the canal is not visible in the best photographs.

The second feature of interest is the "blank" desert region between longitudes 100° and 180°, covering Memnonia, Amazonis, and Arcadia. It was carefully scrutinized on several nights of good seeing. The detailed sketch shows with greatly increased contrast the complex network of faint diffuse markings that cover this area.

Although most of this detail is very faint — the apparent contrast being in the range of 0.1 to 0.05 or less — it is just as real and permanent (or semipermanent) as the better-known darker areas. I had already observed the majority of these faint markings in 1941 with the 8-inch refractor of the Péridier Observatory in Le Houga, France.[9] Some high-contrast multiple prints of the fine photographs taken by W. S. Finsen in 1954 at Union Observatory, South Africa, also show distinctly these faint markings, which are almost always lost in published low-contrast reproductions.

Of particular interest is the small bright region, with a brighter core, located about

The third feature is the region just north of Mare Sirenum on Memnonia, which offers an interesting example of how minor changes of the Martian surface can go unnoticed for many years. On several occasions in September and October, 1941, I had noted a small elliptical spot or oasis just west of the tip of Sirenum Sinus, near 138°, −28°. Westward from this spot a fairly narrow canal extended across Memnonia, crossing the tip of Gorgonum Sinus and ending on the shore line of Mare Sirenum, about halfway between Gorgonum Sinus and Titanum Sinus. This feature did not appear on any map I was familiar with, nor on any other sketches or photographs of 1941 that later came to my attention. (It is, of course, recorded on the map for 1939-41 in *The Planet Mars* and *Physics of the Planet Mars*.)

Over the years I began to wonder if the whole thing had not been an illusion, although it looked real at the time. It was, therefore, with much relief that I saw the formation again in exactly the same place as soon as the region came into view last October (see **23** to **27** and the detailed drawing). The only difference is that the oasis is now much darker, and when the seeing is poor it merges with the tip of Sirenum Sinus, thus seeming to hook back under Sirenum Promontorium.

This oasis is certainly a new semipermanent formation of the Martian surface, since it could not possibly have escaped the attention of all observers since G. Schiaparelli until 1941. A search of the literature disclosed, however, that the canal is not really new; as nearly as can be determined it was observed by Schiaparelli in 1881-82 and is called the Erinnys on his maps. It is also shown on some drawings of G. Fournier in August, 1909.[10]

There is no definite indication of the oasis itself, although in August and September, 1924, a *tout petit lac* was observed under Sirenum Sinus by both E. M. Antoniadi[11] and Fournier.[12] Was this the weak beginning of the present, much stronger formation?

What do canals look like through Lowell's telescope? Of course, I can give only the subjective view of one particular observer, and it is difficult to give an answer that will not be misinterpreted in one way or another, because a satisfactory discussion of canals would require lengthy qualifications and detailed examples. However, a somewhat inadequate summary of my views and impressions follows.

During this or any other opposition, I have never seen anything that could lead me to believe in the objective existence of a planet-wide, geometrical network of long and narrow lines of negligible width, whether natural or artificial.

The bright regions of Mars are, however, neither blank desert expanses, nor are they covered merely by a random distribution of spots out of which the eye creates fictitious lines. The first case is merely an expression of inadequate vision or instrumentation, the second an oversimplified theoretical idea.

Although the eye-brain complex can and occasionally does create illusory lines out of neighboring but unrelated details, this explanation is grossly inadequate to account for most of the linear markings observed on Mars. The main argument against it is the variability of the canals and their peculiar relationships to the great dark areas and major oases.

The canals as seen through the 24-inch refractor looked to me very much the same as they had through smaller instruments in 1937, 1939, and 1941. Some are fairly dark, narrow, and straight, for example the Erinnys (**23** to **27**); others are very dark and broad curved bands, as the variable Nepenthes-Thoth, which was extremely strong this year (**3, 6, 8** through **11**); but the majority are faint, broad, conspicuously diffuse, and occasionally of unequal width, spreading like a fan or horn, as in Gorgon, which fans out northwestward from Gorgonum Sinus (longitude 150°, latitude −25°), or in the streak called Brangaena on Japanese maps (15°, +5°), connecting Oxia Palus to the new westward extension of Sinus Meridiani (**29** and **30**). A good many are merely slightly less bright regions between, or at the edges of, brighter areas.

I have no idea what the origin or meaning of the canal-oasis pattern may be, but I am inclined to share the opinion of Fournier that "the canal phenomenon, by all its properties, is a *specifically Martian phenomenon*."[13] The ultimate fine structure of the canals, and the fact that some can be resolved into minor components and irregular spots under the best seeing conditions, are irrelevant here, for as A. Dollfus remarks, "while generally related in a rather natural way to the [dark] areas in their vicinity, these aspects constitute a very peculiar and specific characteristic of the Martian topography."[14]

Let us now turn to some important atmospheric phenomena of Mars observed during the Flagstaff study. On several occasions, especially October 4th, 11th, and 13th, dull late-afternoon clouds were visible above Libya and over Mare Tyrrhenum, south of Libya. On October 13th (**9**), a persistent prominence appeared at the evening terminator, corresponding to a brighter band in the north polar haze cap in latitude +52°, longitude 200-260°. It lasted for almost three hours and was seen partly detached from the disk. Its average width in latitude was 1.25 seconds of arc (about 300 miles), the maximum apparent height of the projection about 0.45, and the apparent gap between its base and the terminator about 0.15. The computed heights of the top and base of this cloud above the surface, 60 and 40 miles, are probably excessive because of the unfavorable location in latitude. Continual changes were noted from day to day in the extent and structure of the north polar cloud cap, as may be seen in the sketches.

The most remarkable phenomenon was the great, bright, yellowish cloud that appeared above the Lacus Moeris-Libya area (275°, +5°) on October 14th and moved quickly eastward above Amenthes the next day, then southeast above Hesperia on the following days (**10** to **22, 24,** October 14-22). Initially this cloud drifted so rapidly that its motion was detected between the time it was first seen above Lacus Moeris (278°, +10°) at 7:35 Universal time, and the time of the final observation (272°, +5°) at 11:45 UT of the same day.

The cloud's average speed during this four-hour period was about 70 miles per hour. The next day (6:15 to 13:10 UT), it had expanded into a blunted triangle or trapezium, and its center traveled almost due east to 254°, +7°, at an average speed of 35 miles an hour. It then apparently changed course, for on October 16th (7:30 to 11:20 UT) it appeared again above Hesperia (near 240°, −20°), having moved southeast at about 50 miles per hour. On October 17th (9:50 to 10:35 UT), it had moved only a little farther south at some 15 miles an hour and was then encroaching over the southern narrow part of Mare Tyrrhenum, near 232°, −28°, where it remained with little or no change in position until the last observation on October 22nd.

When the region came around to view again the following month, the outline of the cloud was still clearly visible, duller but in exactly the same position (**31** and **32**, November 22-23; compare with the normal aspect of the Hesperia-Mare Tyrrhenum area in **6, 8,** and **10,** October 12-14). It is tempting to interpret these observations as indicating that the dust cloud came to rest and fell back to the surface on or about October 17th; the gradual fading then suggests the idea of dust being blown into cracks of the surface (or shaken off by vegetation?). Further observations of this cloud, especially from Japan, would be of great interest.

As shown in **15** to **21,** additional atmospheric phenomena indicating a prolonged period of activity in the same region were observed over the Lacus Moeris-Libya area after the initial storm, between October 16th and 19th, but they remained well localized and did not move significantly from day to day, although changing in internal detail. It may be that this was low-level dust raised by surface winds and that only occasionally is dust carried to higher levels where it can be picked up by the swift atmospheric currents which, as on the earth, must prevail only in the free atmosphere. It is of some interest that this dust storm took place once more over the same region of Mars and almost to the day at the same season (heliocentric longitude 35° to 39°) as did similar instances of unusual atmospheric activity in 1911, 1926, and 1941, and that it followed very nearly the same path.[15] This clearly indicates an atmospheric pattern that is fairly stable and repetitive at this particular Martian season.

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LETTERS

Sir:

A number of errors appear in the report on page 440 of the June issue, including a middle initial for the writer, even though I do not have one!

The optical system used in the Naval Research Laboratory ultraviolet rocket photography was not one of the three described by University of Colorado scientists in 1954. In previous work, quite a point had been made of using the zero-dispersion arrangement and the second rather than the first grating was figured to correct for astigmatism. We arranged the gratings so that their dispersions add, in order to free the image as much as possible from wave lengths other than Lyman-alpha. For us, the second grating did not recombine the light.

The first grating was ruled on a spherical surface which was later deformed by bending. We have avoided calling this grating ellipsoidal — it was probably more or less toroidal.

The peak altitude of the rocket was 123 miles, but the photographs were made below this. The shortest exposure was 0.02 second rather than 1/200 second.

R. TOUSEY
Rocket Spectroscopy Branch
Naval Research Laboratory
Washington 25, D. C.

MIAMI PLANETARIUM PROPOSED

The Dade County Commission has appropriated a quarter-million dollars for construction of a new museum of science and natural history in Miami, Florida.

Under consideration is a planetarium addition, with a 90-foot exterior dome and a 60-foot chamber seating 350 persons. The planetarium will be built if $600,000 worth of bonds are sold.

The Story of AG Pegasi

PAUL W. MERRILL, *Mount Wilson and Palomar Observatories*

AN inconspicuous star in the constellation of Pegasus is to spectroscopists one of the most interesting objects in the sky. During the past 40 years there have been progressive changes in its spectrum, something observed in very few stars except novae.

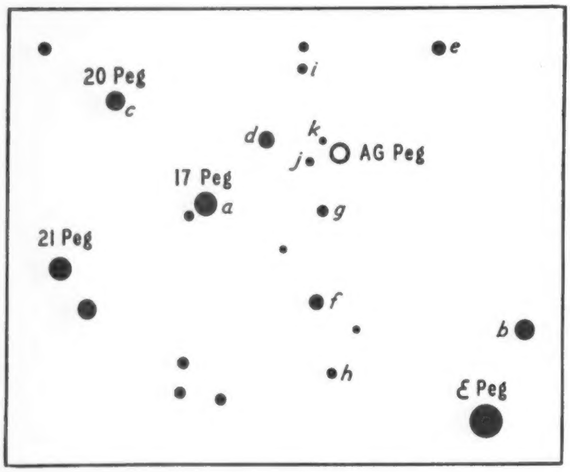


Fig. 1. This field chart of the variable star AG Pegasi was prepared by the French astronomer R. Rigollet for observers using binoculars. He gives the following visual magnitudes for the labeled comparison stars: a, 5.59; b, 6.08; c, 5.55; d, 6.61; e, 6.73; f, 6.75; g, 7.59; h, 7.91; i, 7.75; j, 8.04; k, 8.52. Figs. 1 and 2 are from the French journal "L'Astronomie," July, 1947.

Because its light varies, this 8th-magnitude star has been designated AG Pegasi (Fig. 1). Our knowledge of the light curve is, however, meager. In the past there may have been rather large changes in magnitude, but the observations are extremely sketchy (Fig. 2). Recently the brightness has been slowly decreasing, possibly with 800-day fluctuations of small amplitude.

In the Henry Draper catalogue, AG Pegasi is designated HD 207757, spectrum "peculiar." Most 8th-magnitude *B*-type stars are found near the central plane of the Milky Way galaxy, but this is not true for AG Pegasi. Its position at right ascension $21^h\ 48^m.6$, declination $+12°\ 24'$ (1950 co-ordinates) corresponds to a location 32 degrees below the galactic plane.

Attention was first called to this remarkable star in 1894 by Wilhelmina Fleming's announcement of the presence of bright hydrogen lines in its spectrum. These were found on objective-prism spectrograms taken at Harvard Observatory in the great spectroscopic survey of the sky organized by E. C. Pickering.

Annie J. Cannon's examination of later plates led her to write: "The lines Hβ, Hγ, Hδ, and Hε are bright. Hβ is the strongest and the spectrum is of the P Cygni type." P Cygni stars have broad emission lines with absorption features at their short-wave-length edges. She also suspected the presence of several weak, narrow bright lines between Hβ and Hγ. (These might include lines of ionized iron at 4549, 4583, and 4630 angstroms.) Furthermore, Miss Cannon found no appreciable change in the spectrum on seven plates taken from 1893 to 1912.

In 1894, W. W. Campbell had found the red hydrogen line Hα to be bright, while observing the star visually with the 36-inch refractor of Lick Observatory. The bright lines of the Balmer series indicate the existence of an extended atmosphere of glowing hydrogen gas surrounding the star.

The first slit spectrograms of AG Pegasi were taken by me at the University of Michigan in 1915. Though more detail was visible on these plates than on the earlier ones at Harvard, as far as I could tell the spectrum was the same. Moreover, it appeared essentially unchanged on my first Mount Wilson plates, obtained in 1919. But the very next year things began to happen.

Between 1919 and 1949, I took 130 spectrograms of AG Pegasi at Mount Wilson. An additional 49 were secured from 1950 to 1956, including seven with the 200-inch Palomar reflector, many of them by H. W. Babcock with polarizing apparatus to detect the splitting of spectral lines by magnetic fields (Zeeman effect).

This star has also been studied spectroscopically at the McDonald Observatory in Texas by P. Swings, O. Struve, and G. R. and E. Margaret Burbidge. At the Haute Provence Observatory in France, work has been done by Tcheng Mao Lin and Marie Bloch.

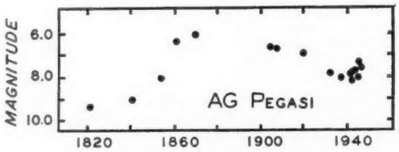


Fig. 2. The brightness changes of AG Pegasi up to 1946 are plotted here by Rigollet, mainly from old observations collected by E. Zinner. About 1820, the star was three magnitudes fainter than it was in the 1870's.

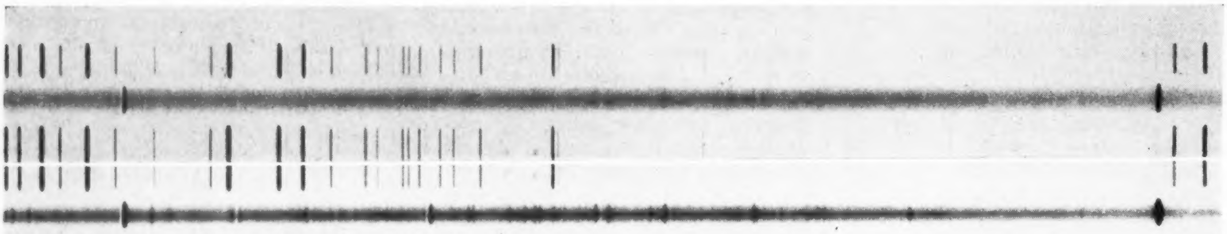


Fig. 3. Spectra of AG Pegasi (with laboratory comparison lines) photographed by the author with the 100-inch reflector, the upper on July 7, 1920, the lower on October 13, 1921. In that interval, the emission lines (dark in this negative reproduction) of hydrogen, neutral helium, and singly ionized iron increased markedly in intensity. The intense line at the extreme right is hydrogen-beta, 4861 angstroms; that at the far left is hydrogen-gamma, 4340 angstroms. Helium lines at 4471 and 4713 angstroms are about 2½ and 5½ inches from the left edge, respectively. Note the developing P Cygni character (absorption edges on the short-wave-length sides) of the 4340 and 4471 lines. All illustrations unless otherwise credited in this article are from Mount Wilson and Palomar Observatories.

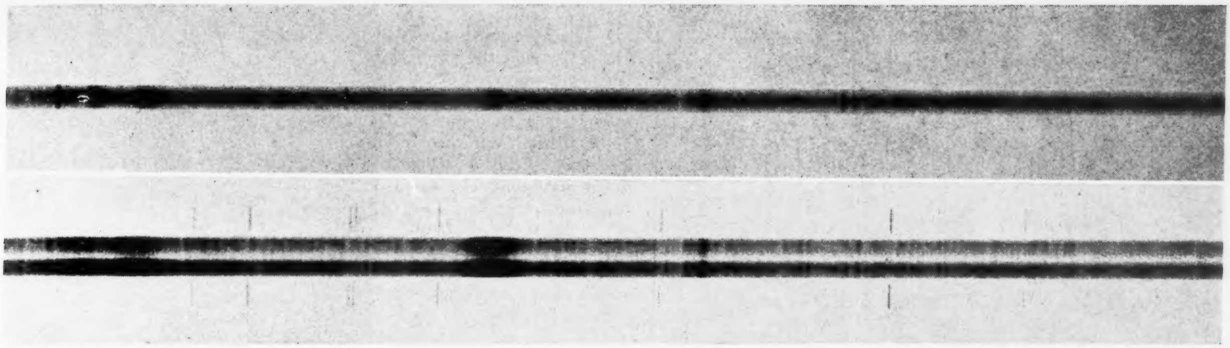


Fig. 4. Two spectrograms obtained with the 100-inch telescope, on July 9, 1944 (above) and August 15, 1954, show further changes in AG Pegasi. About ¾ inch from the left, the doubly ionized nitrogen emission lines at 4634 and 4641 angstroms are greatly intensified, as is the 4686-angstrom line of ionized helium, three inches from the left. Many absorption lines typical of M-type stars have appeared, and an absorption band of titanium oxide has developed, about ¾ inch from the right. The 1954 spectrogram was taken by H. W. Babcock.

The spectroscopic behavior of AG Pegasi is so complex that it is difficult to describe. Cycles of change with a period of 800 days are superposed on a slow general trend which as yet seems to be all in the same direction. As far as we know, both types of change began in 1920.

Let us first consider the progressive changes. We have already noted that prior to 1919 bright hydrogen lines were a prominent feature of AG Pegasi's spectrum. Several other elements, including iron, silicon, nitrogen, and aluminum, were represented by weak emission lines.

The lines of neutral helium were dark, as expected in a normal *B*-type spectrum. But in 1919 these absorption lines of helium became weaker, and in 1920 they were replaced by bright lines which grew stronger in following years. This outburst was accompanied by an increase in the strengths of bright lines of several other elements (Fig. 3). Altogether more than 450 bright lines, many of variable intensity, have been measured between 3256 angstroms in the ultraviolet and 6678 angstroms in the red. At times 50 or more of these have been accompanied by dark components on the side toward shorter wave lengths — the P Cygni characteristic.

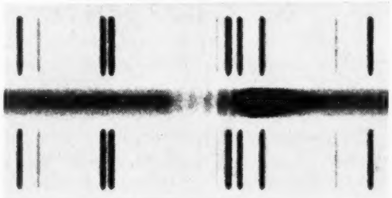


Fig. 5 (left). Part of a spectrogram obtained by H. W. Babcock with the 100-inch telescope on June 29, 1950, shows the remarkable structure of the 3888-angstrom line of neutral helium. The broad emission component (black) has a velocity of approach of 22 kilometers per second, and there are up to 10 superimposed absorption components of from 66 to 452 kilometers per second approach.

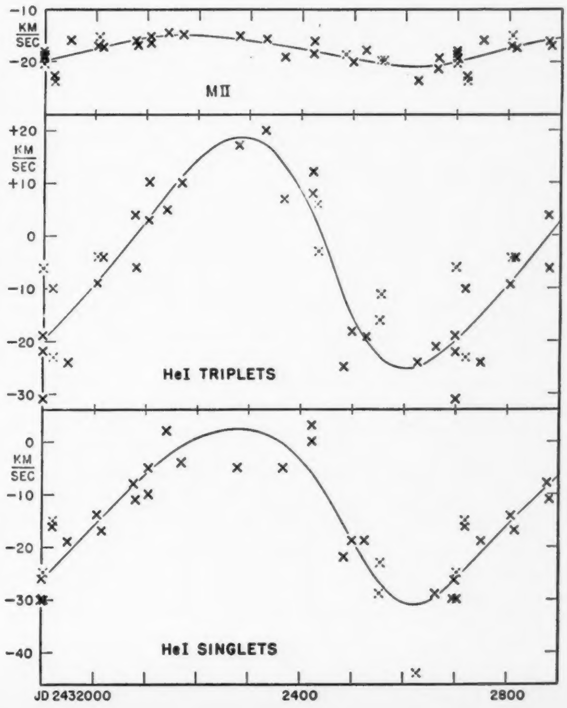


Fig. 6 (right). Compare these radial velocity curves of the ionized metals (M II) and neutral helium during the 800-day cycle.

Since about 1922, the spectrum has gradually developed the features typical of *symbiotic* stars. This biological term applies to a group of anomalous stars with spectra that combine apparently unrelated characteristics. Emission lines requiring high excitation energies (such as the principal lines in the spectra of nebulae and the line of ionized helium at 4686 angstroms) are superimposed, in a quite unorthodox fashion, on an absorption spectrum typical of a low temperature star, usually of stellar type *M* (Fig. 4). Thus, two objects of quite different kinds seem to be living close together in extraordinary interdependence and adjustment.

About 25 stars of this kind are known, of which Z Andromedae is the prototype. Outstanding bright lines were discovered in its spectrum in the early Harvard survey, and in 1927 H. H. Plaskett studied it thoroughly at the Dominion Astrophysical Observatory. Other symbiotic stars are AX Persei, RW Hydrae, BF Cygni, and CI Cygni. As a recent addition to the list, AG Pegasi may help us understand the intriguing, yet mysterious peculiarities of these strange objects.

AG Pegasi was formerly a *B*e star, but beginning about 1922, an *M*-type spectrum with dark lines of neutral metals and dark bands of titanium oxide has gradually emerged. A most interesting progressive change has been the slowly increasing negative displacement of the absorption lines. Negative displacement (toward shorter wave lengths) means motion toward us but *away from the star.* This suggests that a strong outflow of gas from a central region may be involved in symbiotic phenomena.

As the *M*-type spectrum emerged, certain emission lines of ionized iron, nitrogen, and silicon (Fe III, N III, Si III and IV), and the helium 4686 line, all of which require high excitation, have become more intense. The chief nebular lines were first noticed in 1942, and by 1950 they were well marked. In 1956, the nebular lines whose wave lengths could be determined included 4363, 4959, and 5007 angstroms, forbidden lines of twice-ionized oxygen [O III], and of twice-ionized neon [Ne III] at 3869 angstroms;

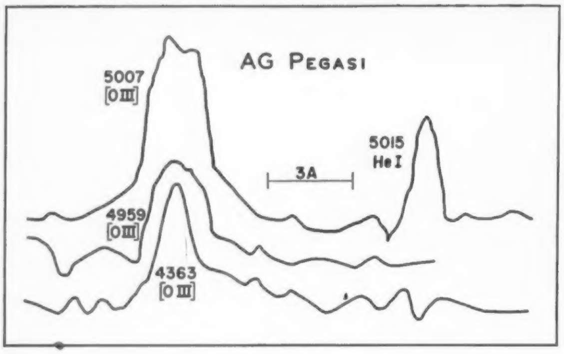
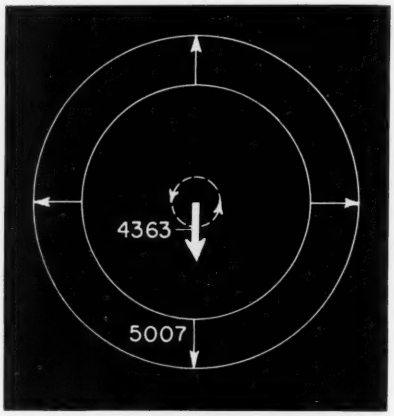


Fig. 7. Measured profiles show that the 4363-angstrom oxygen line of AG Pegasi is much narrower than the one at 5007. This is explained by the author's schematic model of the system, at the right. The 5007 light comes from an outer expanding envelope, 4363 from a jet much closer to the central star.



the cyclical behavior of these lines is described below.

In 1915 and earlier, the bright hydrogen lines had dark components on their short-wave-length edges. Such a phenomenon is explained by an expanding atmosphere around the star. All parts of it emit light, producing the emission lines, but the section lying in front of the star's disk or photosphere absorbs more light than it emits. Since this part of the atmosphere is expanding toward the observer, there is a Doppler displacement of the absorption line toward the violet end of the spectrum. In AG Pegasi, the dark components of the hydrogen lines are not very strong and sometimes disappear.

Although the absorption lines of other elements showed no outward motion in 1915, by 1950 they were displaced by a velocity of approach of 200 kilometers per second!

The behavior of the neutral helium line at 3888 angstroms is almost incredible. In addition to a wide bright line (blended with Hζ of hydrogen) whose center is probably close to the normal position, from two to eight discrete dark components have been observed, their negative displacements corresponding to outward motions ranging from 44 to 406 kilometers per second (Fig. 5). These components exhibit rapid and apparently irregular variations in position and intensity. The only progressive change appears to have been the occasional addition, between 1943 and 1950, of components with greater and greater velocities.

How outbound shells exhibiting so many discrete velocities can exist at the same time is not understood, and plausible hypotheses are needed. On one point the evidence is strong. The absorbing zones are far above the photosphere; this follows from the intensity and narrowness of the components. Thus the word *shell* carries the proper connotation.

Let us now turn to the periodic changes. Since 1920, the bright lines of various elements have shown oscillations in position (radial velocity) and intensity in a persistent 800-day period. But the radial velocity curves derived from lines of various elements agree only in their period, differing in phase, amplitude, and mean velocity (Fig. 6). Several types of behavior seem to be involved, and it has not been possible to assign the lines to one or the other component of a binary star system. The true explanation is certainly much more complicated, and may involve streams of gas coursing about under the complex gravitational control of two or more stars. Perhaps electromagnetic forces also are involved.

Change rather than stability is the rule in this odd star. The velocity curve of a particular element may vary from time to time. For example, the average velocity of the bright hydrogen lines changed from a recession of 16 kilometers per second in 1915 to an approach of 27 in 1952. So far, however, all velocity curves have maintained the 800-day period. Since 1919 this has been about the only stable feature of AG Pegasi.

Recent high-dispersion spectrograms show that the forbidden O III line at 4363 angstroms is fairly narrow, with velocity changes amounting to about 68 kilometers per second in the 800-day period. But two other forbidden lines of O III are wider and they have a range of less than 20 kilometers per second (Fig. 7). It is well known that the intensity of the 4363 line relative to that at 5007 angstroms increases with the density of the emitting gas. If the gaseous layers of AG Pegasi are expanding, the density near the center would be higher than it is farther out. Thus we conclude that 4363 is emitted chiefly near the star itself, 5007 in some outer zone.

Moreover, the velocity variation of 4363 suggests that it comes from a revolving central jet of gas that alternately points toward and away from the observer. The greater width and smaller range of the other O III lines indicate that they come from an outer zone where they combine, on any one spectrogram, all the relative velocities shown by the 4363 line through the cycle. For example, the 5007 line is broad and flat, with a width that corresponds to a velocity spread of 114 kilometers per second. The geometry of these interpretations is shown schematically in Fig. 7.

Presumably the central jet is pulled around by one member of a binary system. This hypothesis resembles that formulated by O. Struve to explain certain peculiarities in the eclipsing binaries Beta Lyrae and UW Canis Majoris. Phenomena supposedly due to a revolving jet have been called the *hose effect* by Cecilia Payne Gaposchkin.

Future observations of AG Pegasi should aid our understanding of symbiotic stars and of stellar atmospheres in general. Accurate light curves, in two or more colors, may help explain the increasing dominance of the *M*-type component. We would also like to know more about AG Pegasi's magnetic field, for which Babcock's emission-line observations show a variation of intensity from +520 to −1,800 gauss. On two plates, absorption lines in the *M*-type spectrum gave values of the same order. But most important of all would be observations in the extreme ultraviolet portion of the spectrum, which may some day be made from instruments placed outside the earth's atmosphere.

DUTCH ECLIPSE PLANS

An expedition to the Canary Islands for the total solar eclipse on October 2nd is being planned by the Netherlands eclipse commission of the Dutch Academy of Sciences. The scientists will leave for the eclipse site about August 15th. Under the leadership of J. Houtgast, astronomers from Utrecht Observatory will set up their instruments on the island of Fuerteventura, near the harbor of Gran Tarajal.

The island has a climate comparable to the Sahara Desert; there are no trees and only a few water sources. Weather expectations are good, and the location is satisfactory with respect to prevailing winds and mountains. This site was selected because it is near the edge of the totality belt, where the solar chromosphere remains visible for a much longer time than on the central line.

The Dutch will continue the work they did at the eclipses of 1952 and 1954: investigation of the chromosphere and the photometric determination of its radiation at different heights. In particular, it is planned to study the flash spectrum in ultraviolet and visible light, the continuous radiation of prominences, and the radiation of the last photospheric crescent, in four colors.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 102nd meeting of the American Astronomical Society at Rochester, New York, in March, 1959. Complete abstracts will appear in the Astronomical Journal.

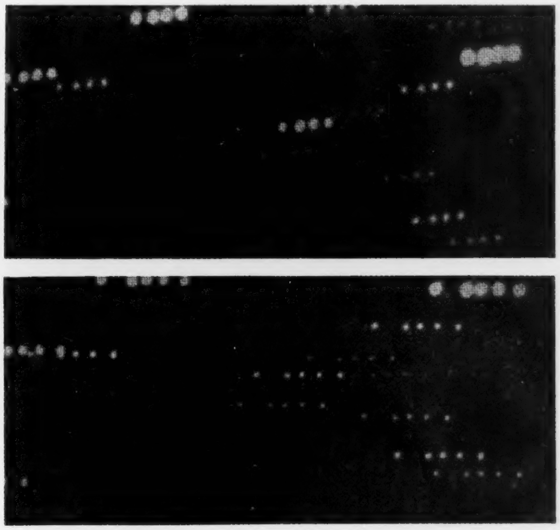
VV Puppis

A faint variable star in the constellation Puppis has turned out to be a remarkable eclipsing binary system, according to George H. Herbig, Lick Observatory. Its period of revolution of 100 minutes is less than that of any other known binary, and is the shortest period of orbital motion known in astronomy (except for artificial earth satellites).

The light variations of this star, VV Puppis, were discovered in 1931 by H. van Gent, of Leiden Observatory, on photographs taken in South Africa. For a few years, this object held the distinction of being the variable with the shortest known period. Although originally classified as an RR Lyrae star, VV Puppis differed markedly from other members of that group.

The light curve was peculiar, having a gradual rise to maximum and rapid descent to minimum; the light variations showed changes from cycle to cycle; and there was a slow year-to-year decline in the average brightness of the variable, amounting to two magnitudes by 1948 and 1949. Sometimes the light variations would cease altogether, and once the star did not brighten from its minimum photographic magnitude of 17.0 for 250 cycles, an interval of 18 days. Nevertheless, whenever the fluctuations resumed, the maxima would occur right on the schedule maintained since discovery.

Late in 1958, when VV Puppis was about a magnitude brighter than it was a decade earlier, Dr. Herbig made spectroscopic observations with the 36-inch Crossley reflector. They show clearly that this star is not of the RR Lyrae type. The spectrum consists of a continuous bright background such as a hot star would produce, extending well into the ultraviolet, that is dominated by strong emission lines of hydrogen and ionized helium. No absorption lines are detectable.



Multiple-exposure photographs of VV Puppis taken with the 74-inch reflector of Radcliffe Observatory, Pretoria, South Africa. The variable star is just above the center of each picture. In the upper one, on February 22, 1949, VV Puppis is followed through a maximum (magnitude 15.1) of its 100-minute cycle. The other picture, taken on March 25th of the same year, shows the star quiescent at magnitude 16.8. Illustrations on this page are from the "Bulletin" of the Astronomical Institutes of the Netherlands.

The emission lines show large changes in wave length during the 100-minute cycle. Dr. Herbig interprets these displacements as due to orbital motion, and represents them by spectroscopic elements with a half-range in velocity of 437 kilometers per second and an orbital eccentricity of 0.09. The emission-line star is behind the other component just after the steep decline from maximum light.

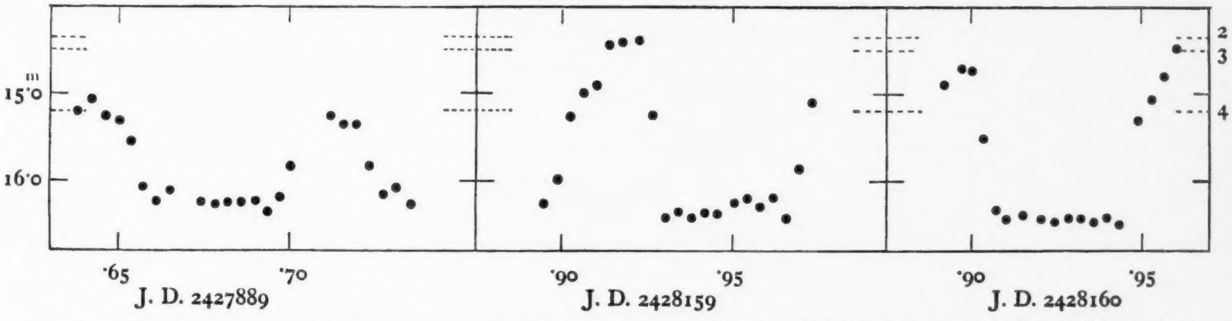
In Dr. Herbig's interpretation, VV Puppis is composed of a small dark star and a larger one, whose widespread surface activity is responsible for the emission lines. The side of the larger star that is to the rear with respect to the orbital motion also contains a bright, hot area that produces the strong continuous spectrum. The system appears brightest when the "hot spot" is nearly central on the disk, but, when the dark star moves across, the spot is quickly covered. By the time the eclipse is over, the hot area has already vanished around the larger star's limb, so the system remains faint until the bright area comes into view again, brightening slowly as more and more of the spot is exposed. It is possible to account in this way for the long duration of minimum, lasting over half of the cycle.

The California astronomer suggests that the progressive decline in the brightness of VV Puppis probably resulted from intrinsic variation of the larger, emission-line star. The cycle-to-cycle changes in the light curve may be accounted for by alterations in the size and brightness of the hot area.

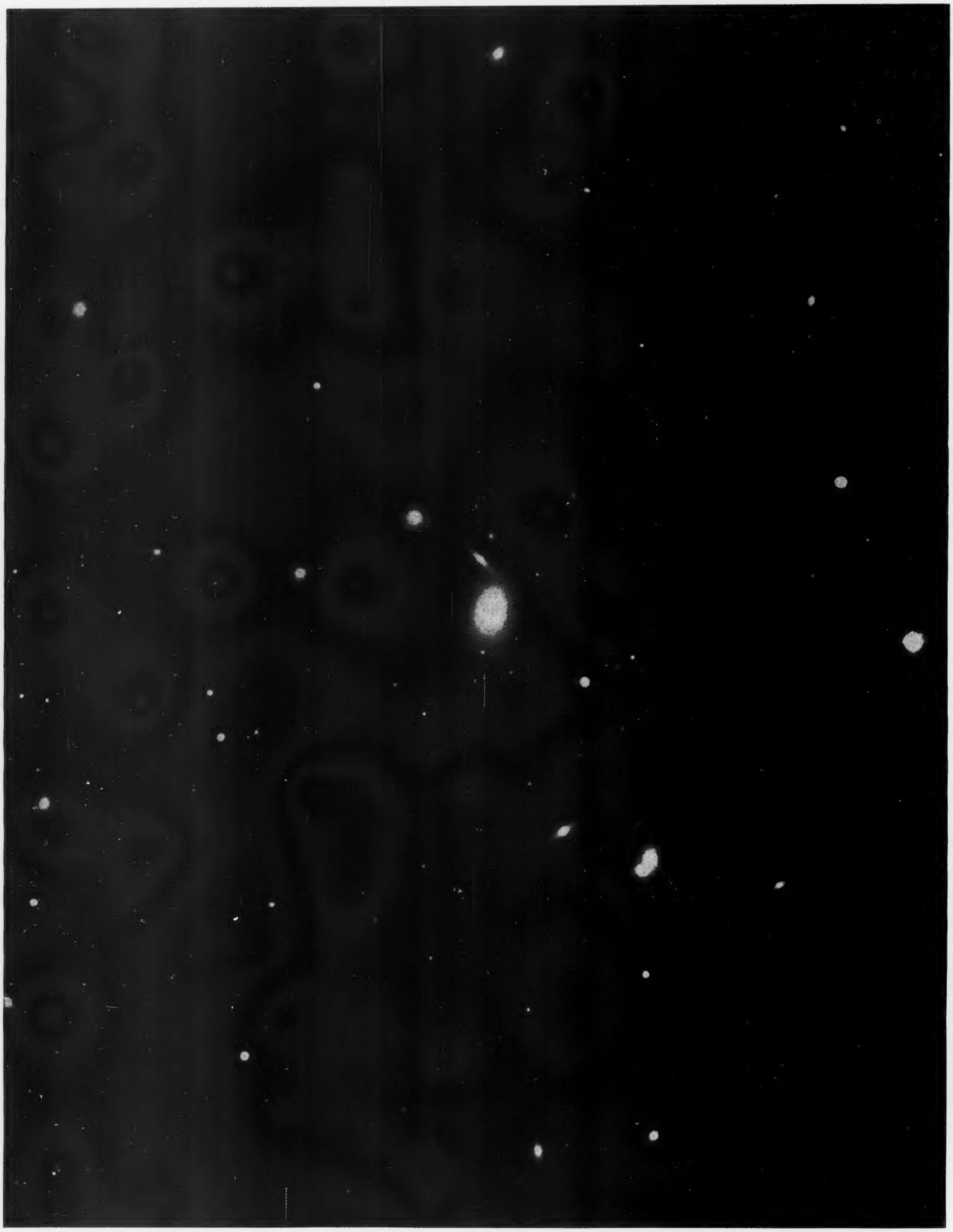
Lithium in K Stars

There are some notable exceptions to the general agreement among the earth, the sun, and normal Population-I stars in the relative abundances of the elements they contain. For example, the earth is lacking in hydrogen and helium, and lithium is far commoner on the earth than in the sun.

In order to find if cool stars in general



Photographic observations of the brightness of VV Puppis on three nights in 1935 by P. T. Oosterhoff, with the 60-inch Mount Wilson reflector. The dashed lines indicate the magnitudes of the three comparison stars that H. van Gent used for observing this star in 1928-31, when it averaged a magnitude brighter.



Part of the great cluster of galaxies in Coma Berenices, from a photograph with the 200-inch Hale telescope. Each of the fuzzy objects is a distant counterpart of our Milky Way system. This cluster was first recognized by the German astronomer M. Wolf in 1901. Long thought to be less than two degrees in diameter, it was shown on F. Zwicky's photographs with the 48-inch Schmidt telescope to be some 12 degrees across, with about 9,000 members brighter than photographic magnitude 19. The center of the Coma cluster is at $12^h\ 55^m$, $+28°.3$. Its brightest member is about magnitude 13, and only three or four of its galaxies are in the "New General Catalogue." Mount Wilson and Palomar Observatories photograph.

are deficient in lithium, W. K. Bonsack, California Institute of Technology, has measured the abundance of that element relative to vanadium for 46 stars with spectra of or near class *K* (*G*8 to *M*0 inclusive). His observations were made with the coude spectrograph of the Mount Wilson 100-inch reflector. On high-dispersion spectrograms, he compared the intensity of the neutral lithium line at 6708 angstroms with a number of lines of neutral vanadium.

Among stars of similar surface characteristics, the abundance ratios thus found differed by as much as a factor of 100, and none had more lithium relatively than the sun. Nevertheless, there was a tendency for cooler stars to contain less lithium relative to vanadium. Dr. Bonsack feels that this tendency is not due, in any significant degree, to differences in vanadium content. Instead, he suggests that both the trend and the variations are the result of convective transport of lithium from the surface layers of cool stars into their interiors. This mechanism had earlier been proposed by J. L. Greenstein and R. S. Richardson to explain the deficiency of lithium in the outer parts of the sun.

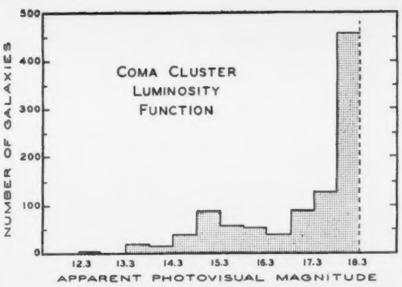
Coma Cluster of Galaxies

In the constellation Coma Berenices is a remarkable concentration of thousands of faint galaxies, mostly of the elliptical type, within an area a dozen degrees across. Because the members of this cluster can be considered to be approximately the same distance from us, a comparison of their apparent magnitudes gives direct information about their relative intrinsic luminosities.

G. O. Abell, of the University of California at Los Angeles, has used observations with the 48-inch Palomar Schmidt telescope to determine the numbers of galaxies in successive magnitude intervals — the luminosity function — for the Coma cluster.

First he measured the magnitudes of a number of stars in the same field as the cluster, using photographic and photoelectric methods. Then the magnitudes of the galaxies were obtained by comparison with these stars on out-of-focus photographs. Five such plates of the cluster were used, taken at different extrafocal settings, and each galaxy was measured on at least two of them. The entire procedure was carried out twice to obtain both blue and yellow magnitudes, the limit of the observations being about photographic magnitude 19.2.

As the accompanying diagram of the results in yellow light indicates, the number of galaxies increases rapidly with increasing faintness. However, there is a distinct secondary peak in the numbers, which occurs about two magnitudes fainter than the brightest cluster members. This feature confirms similar findings by W. Baade and G. de Vaucouleurs.



The number of galaxies within successive half-magnitude intervals of brightness is plotted here by G. O. Abell. The secondary peak near magnitude 15 may provide a new way to find cluster distances, he suggests.

The presence of the peak does not depend on galaxy color, because Dr. Abell made separate counts for galaxies with color indices greater than 0.4 magnitude and for those with smaller indices, finding that both gave diagrams with the secondary maximum.

If further studies should show that this subsidiary peak near the bright end of the curve is a general property of clusters of galaxies, it might serve as a useful criterion for finding their relative distances.

Dr. Abell is making observational studies of about 30 more rich clusters of galaxies, using the same photometric techniques.

Spectra of Supernovae of Type I

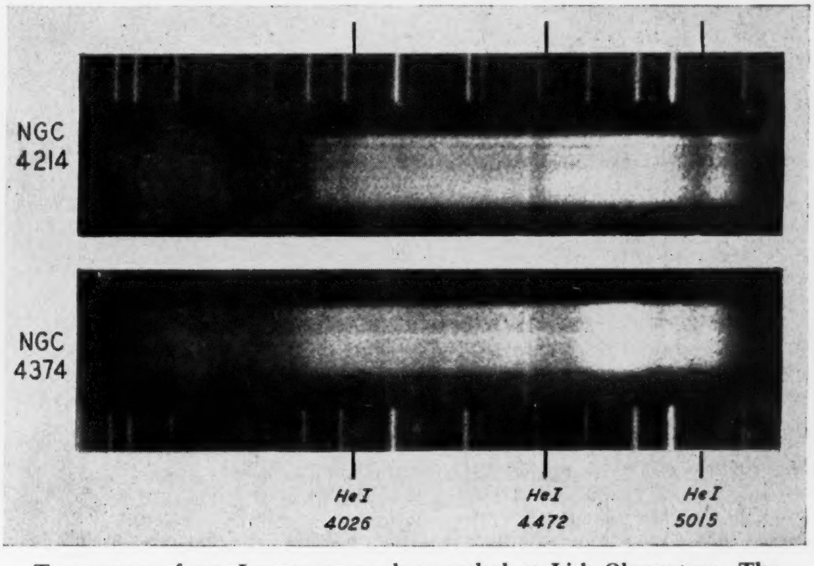
Supernovae are stars that suddenly burst into brilliance to reach temporary brightnesses equal to some 100 million suns for type I, and about 10 million suns for type II. A supernova occurs on an average of once every several centuries in any one galaxy. Their high luminosities permit us to observe them at great distances.

The usual supernova of type I has a spectrum that appears to be composed of very broad and diffuse bright bands, none of which has ever been satisfactorily identified. For several months after maximum light, the emission bands in the red-to-green region change in strength but do not alter their wave lengths. In the blue-violet region, however, the bands shift steadily toward longer wave lengths without much change in character — an unexplained behavior.

University of Michigan astronomer Dean B. McLaughlin has studied spectrograms, taken at Lick and at Mount Wilson and Palomar Observatories, of the supernova that appeared in 1954 in the irregular galaxy NGC 4214. While clearly representative of type I during its later spectral stages, the spectrum of this supernova differed considerably from normal during the sixth to tenth week after maximum light.

The blue region appeared nearly like a continuous spectrum crossed by a few strong and several weak absorption lines. Two of the strongest can be interpreted as being those of neutral helium at wave lengths of 4026 and 4472 angstroms, but displaced by an amount corresponding to a velocity of approach of 5,000 kilometers per second. The fainter absorption lines, nearly all attributable to neutral helium and ionized carbon, oxygen, and nitrogen, indicate a similar velocity, which may be interpreted as a rapid outward expansion of gases from the star itself.

Deep, very broad absorption features at wave lengths of 4900 and 3800 angstroms are not fully explained, but may be caused in part by neutral helium. Dr. McLaughlin pointed out the resemblance of this pattern of dark lines to the spec-



Two spectra of type-I supernovae, photographed at Lick Observatory. The supernova in NGC 4374 was normal, but the upper spectrum, taken June 24, 1954, has peculiar weak absorption features, labeled here, which D. B. McLaughlin attributes to helium.

trum of the star HD 124448, which is classified as type *B* but lacks hydrogen lines.

From June 6 to July 8, 1954, the *B*-type absorption spectrum of the supernova shifted to longer wave lengths, the mean velocity of approach changing from 5,700 to 4,700 kilometers per second. It was suggested by Dr. McLaughlin that the apparent shifting of the blue-violet emission in all type-I supernova spectra might actually be the effect of a slowing in the expansion of the layer of the star's atmosphere in which absorption lines are produced. This layer would lie above the one where the general emission in a supernova originates. Presumably the dark lines are so broad and hazy in most cases that they have gone unrecognized. However, the Michigan astronomer points out that this proposal does not account for the lack of a similar shift in the red-green emission features.

Far-Ultraviolet Solar Spectrum

Since rockets became available for astrophysical purposes, the Naval Research Laboratory has carried on a continuing study of the extreme ultraviolet radiation emitted by the sun. Previous observations have shown that the solar spectrum, below a wave length of 1800 angstroms, changes from a continuum with Fraunhofer absorption lines to a spectrum of emission lines, dominated by the Lyman-alpha line of hydrogen at 1216 angstroms.

J. D. Purcell and his coworkers at the NRL obtained new spectrograms of the sun in the wave length range from 500 to 2100 angstroms, during the flight of an Aerobee-Hi rocket on March 13, 1959. This was the same ascent during which the Lyman-alpha solar photograph described on page 440 last month was taken. W. R. Hunter, D. M. Packer, and R. Tousey also worked on the program.

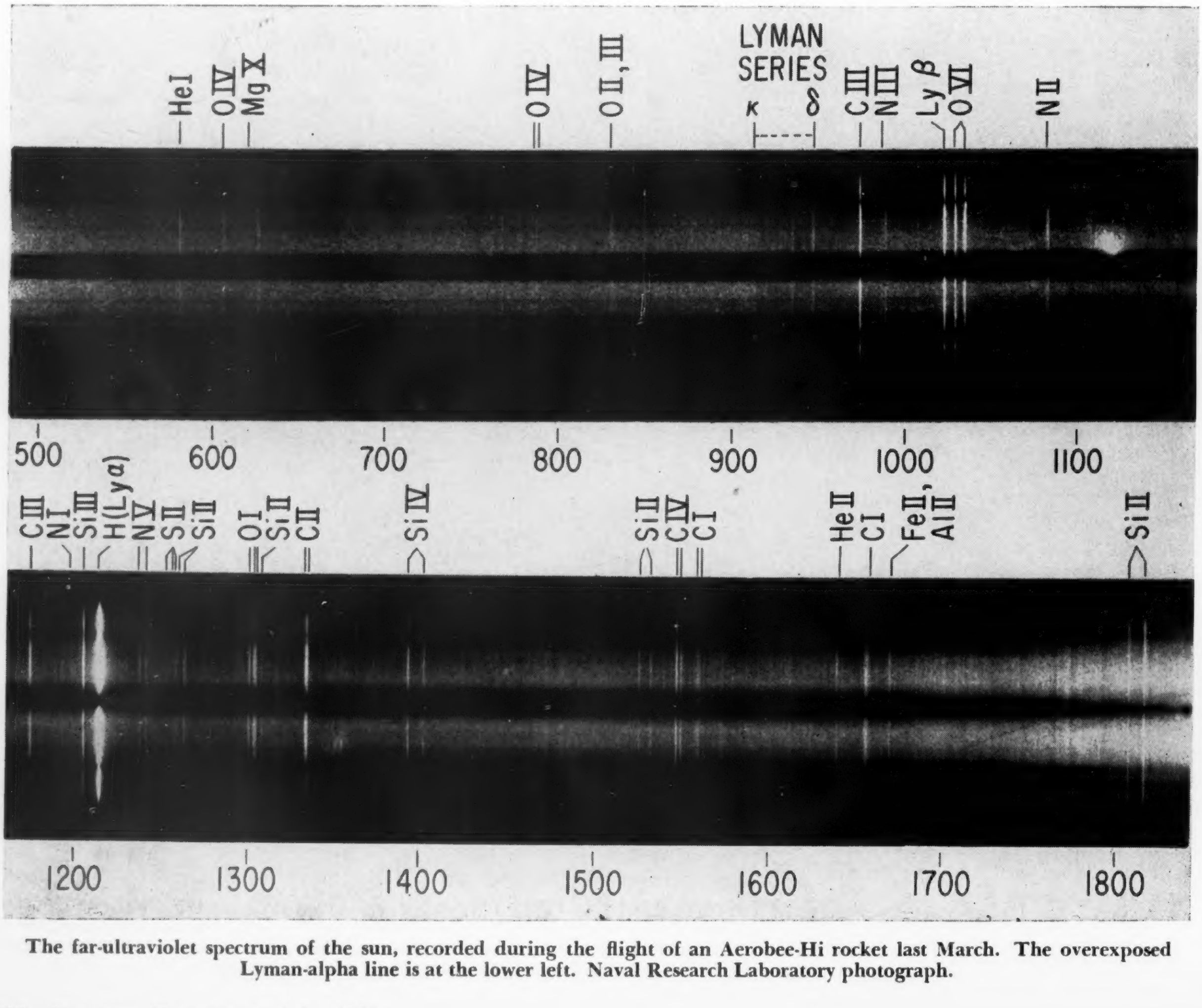
Since the surface coatings of the spectrograph gratings had higher reflectance in the extreme ultraviolet than those previously used (see page 502 of August, 1958), the new spectra contain far more detail. More than 100 emission lines were observed, of which only about 40 had been noted earlier. Though the analysis is still in progress, preliminary results indicate that the most intense lines appearing on the spectrogram reproduced here are due to neutral hydrogen and helium, along with neutral or ionized silicon, carbon, oxygen, nitrogen, sulfur, and magnesium. The black streak through the middle of the picture was caused by dust on the spectrograph slit.

At least six lines have been identified in the Lyman hydrogen series, which ends at a fairly abrupt rise in the background density. This indicates the presence of the Lyman continuum, beginning at 910 angstroms and extending to shorter wave lengths.

Further work is being done to measure the intensities of the lines. The data thus obtained bear directly on the processes taking place in the earth's upper atmosphere. The results will also give a better understanding of the structure of the sun's atmosphere.

AMERICAN ASTRONOMICAL SOCIETY MEETING

The 103rd meeting of the American Astronomical Society will be held in Canada at the University of Toronto, August 30-September 2. The program will feature a symposium on the differences among globular clusters and a visit to the David Dunlap Observatory. On Tuesday, September 1st, Dr. Gerard P. Kuiper, Yerkes Observatory, is to give the Russell lecture, "Planets and Satellites."



The far-ultraviolet spectrum of the sun, recorded during the flight of an Aerobee-Hi rocket last March. The overexposed Lyman-alpha line is at the lower left. Naval Research Laboratory photograph.

Nova Herculis as a Binary System

Otto Struve, *Leuschner Observatory, University of California*

FIVE YEARS AGO Merle F. Walker, then working at Mount Wilson Observatory, made the surprising discovery that the nova DQ Herculis is an eclipsing binary star. During December, 1934, this nova reached a maximum brilliance of magnitude 1.3, but had faded to about 14 when Walker made his photoelectric observations two decades later.

There is only one other known case of a nova in a binary system. However, this does not rule out the possibility that many novae may have close companions, which would be very difficult to detect.

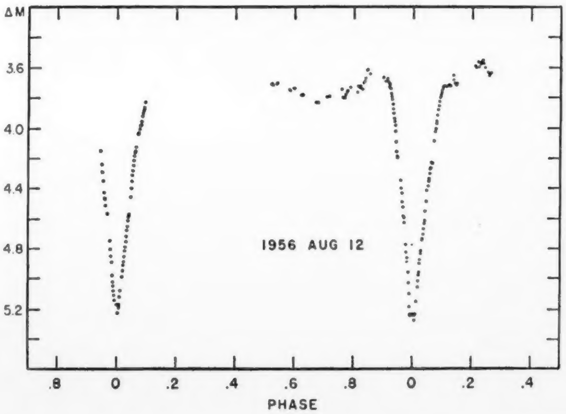


Fig. 1. This night's run of photoelectric observations in yellow light by M. F. Walker follows DQ Herculis through two primary eclipses. The vertical scale is the difference in magnitude between the nova and a comparison star. From the "Astrophysical Journal."

Two stars, SS Cygni and AE Aquarii, whose outbursts resemble those of ordinary novae but are less violent, are close doubles. Moreover, the period of light variation and other features of the light curve of DQ Herculis bear a strong resemblance to those of UX Ursae Majoris, as told in Sky and Telescope for May, 1955, page 275. Thus, the duplicity of Nova Herculis may not be an isolated phenomenon.

Primary eclipses of the nova by an invisible companion recur every four hours and 39 minutes, but there is no indication of a secondary minimum between the primary ones (Fig. 1). The latter are quite deep — about 1.2 magnitudes — which suggests that these eclipses are total or very nearly so, and that the invisible occulting star has a much lower surface brightness than the nova itself.

Perhaps of greater significance is the even more remarkable discovery made by Walker immediately after he had found the binary nature of DQ Herculis. Normally, after ejecting perhaps a hundred-thousandth of its mass in a nova outburst, a star returns in the course of a few decades to its pre-nova state — an underluminous blue star, sometimes without any absorption or emission lines in its spectrum — and eventually shows only minor, irregular variations.

But the light curve of Nova Herculis, outside of eclipse, contains small, strictly rhythmic oscillations (Fig. 2) whose period is 71.0604 *seconds,* with an uncertainty of only ±0.00035 second — a very striking degree of precision. The amplitude of these oscillations is not always the same; usually they amount to a few hundredths of a magnitude, but at times they are too small to be detected. However, when these waves in the light curve can be observed, the maxima and minima occur exactly on schedule. Evidently the oscillations are always present, even when unrecorded.

The strict periodicity suggests that the nova is pulsating like a Cepheid variable but far more rapidly, since it contracts and expands in a cycle of only 71 seconds, instead of 5.37 days as for Delta Cephei. There is a well-known law that holds for all pulsating stars: The period in days multiplied by the square root of the mean density (in terms of the sun's) is a constant, near 0.1 in each case. For example, the mean density of Delta Cephei is 0.0006 times the sun's; multiplying the square root of this number by the period, 5.37 days, gives 0.13 for the constant.

If we use this value in applying the law to Nova Herculis, with a pulsation period of 71 seconds or 8×10^{-4} day, we find

$$(\text{Density})^{\frac{1}{2}} = 0.13/(8 \times 10^{-4}).$$

Thus the mean density of the nova is about 25,000 times the sun's, or 35,000 grams per cubic centimeter!

Although a drastic extrapolation has been made in this calculation, theoretical studies by I. Epstein in 1950 and E. Sauvinier-Goffin in 1949 lend support to it. There can be no doubt that the nova is an extremely dense star, resembling a white dwarf in this respect.

In 1956, Robert P. Kraft observed the spectrum of Nova Herculis, using the prime-focus spectrograph of the 100-inch Mount Wilson reflector. His measurements showed that the radial velocity, determined from several emission lines in the nova spectrum, varied in synchronism with the cycle of eclipses. Two years later a new series of spectrograms was obtained by J. L. Greenstein with the 200-inch telescope. Their papers in the *Astrophysical Journal,* the first by Kraft and Greenstein, the second by Kraft alone,

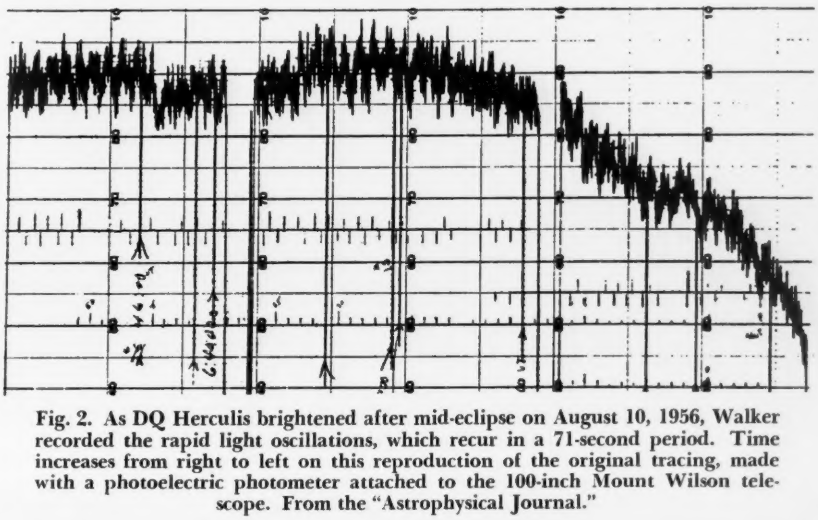


Fig. 2. As DQ Herculis brightened after mid-eclipse on August 10, 1956, Walker recorded the rapid light oscillations, which recur in a 71-second period. Time increases from right to left on this reproduction of the original tracing, made with a photoelectric photometer attached to the 100-inch Mount Wilson telescope. From the "Astrophysical Journal."

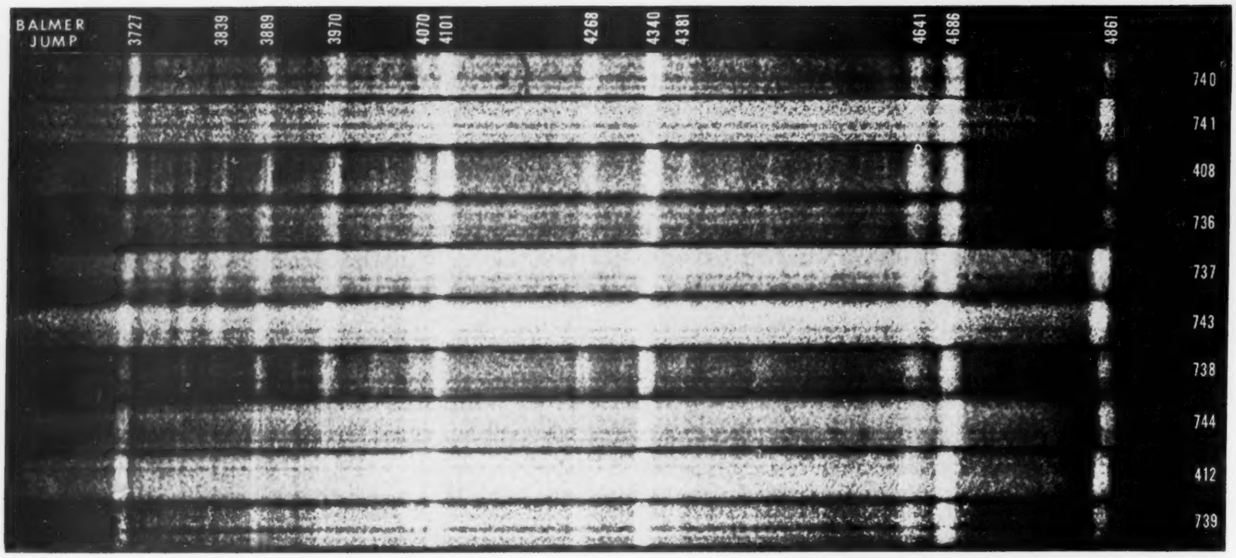


Fig. 3. Ten spectrograms of DQ Herculis taken with the 200-inch telescope have been arranged in order of phase to show spectral changes during the 279-minute cycle. At the right are plate numbers; the corresponding phases, counted in fractions of the period beginning with mid-eclipse, are: 0.01, 0.26, 0.32, 0.40, 0.52, 0.67, 0.67, 0.81, 0.82, and 0.82. At the top are wave lengths, in angstrom units, of some of the conspicuous emission lines, including 3727, a forbidden line of ionized oxygen; 3839, 3889, and 3970 – higher lines of the Balmer hydrogen series; 4070, a forbidden ionized sulfur line; 4101, hydrogen-delta; 4340, hydrogen-gamma; 4686, ionized helium; and 4861, hydrogen-beta. The spectra on these two pages are from Mount Wilson and Palomar Observatories.

summarize the results of the combined observations.

The accompanying set of 10 spectrograms, supplied by Kraft and Greenstein, shows how the spectrum changes during the course of an orbital cycle of DQ Herculis. Here the phase is the fraction of a period that has elapsed since mid-eclipse, corresponding to 0.00. Phases 0.25 and 0.75 represent the times of elongation of the components as seen from the earth – when the stars are side by side in the plane of the sky.

The spectrum consists of a continuous band with strong emission lines. The latter are produced partly in the large expanding nebulous envelope that was blown off during the nova's outburst in 1934, and partly in a much more compact nebula surrounding the pulsating component of the binary.

Members of the hydrogen Balmer series at longer wave lengths, Hβ, Hγ, and Hδ, change little if at all with phase, indicating that they arise mostly in the large envelope. On the other hand the higher Balmer lines, at shorter wave lengths, vary in intensity, being faintest during eclipse and brightest at about phase 0.6. They appear to originate mainly in the compact nebula.

This interpretation by Kraft and Greenstein was confirmed on short-exposure spectra obtained in rapid succession during three eclipses of the nova. As the invisible companion passed in front, the higher members of the Balmer series faded much more than Hβ or Hγ (Fig. 4). In the same way, it was demonstrated that the emission line of ionized helium (He II) at a wave length of 4686 angstroms comes mostly from the small nebula, while the forbidden oxygen line at 3727 angstroms originates primarily in the large envelope.

As the illustrations show, the higher Balmer lines change in shape as well as brightness during the cycle. They are double near phases 0.25 and 0.75; in the former case the longer-wave-length component of each line is stronger, while the opposite is true in the latter.

The double character of Hζ at 3889 angstroms is easy to see in Fig. 5. For members of the Balmer series toward shorter wave lengths than this, the confusion of double components among the closely spaced emission features is more difficult to disentangle. The helium line at 4686 angstroms is also undoubtedly double, but its duplicity is harder to recognize than that of Hζ.

In Fig. 5, the spectra have been exactly aligned with respect to wave length, by means of the comparison lines. It is easily seen that Hβ, Hγ, and the oxygen line at 3727 angstroms show practically no displacement between phases 0.32 and 0.82 – near the elongations – whereas the He II line is shifted toward the red at phase 0.82.

From measurements of the Doppler displacements of the outer edges of the He II line at 4686 angstroms, Kraft and Greenstein have plotted the radial velocity curve shown in Fig. 6. The black dots represent 200-inch observations, open circles those with the 100-inch. At phase 0.3 the greatest velocity of approach is attained (except for an anomaly discussed below), and at phase 0.8 the greatest recession, the plotted points forming a sine curve.

This indicates that the nova is moving with a speed of 150 kilometers per second in a roughly circular path around the center of gravity of the system, at a projected distance of about 250,000 miles. The radial velocity measurements also indicate that the binary system and the sun are approaching each other at 20 kilometers per second.

Of particular interest is the anomalous

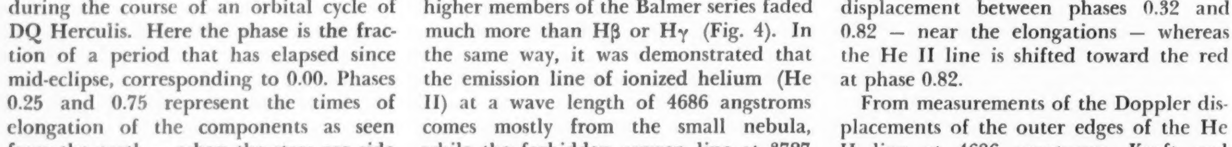


Fig. 4. J. L. Greenstein took on one plate five exposures in rapid succession during a single eclipse. Their phases, from bottom to top, are: A, 0.90; B, 0.93; C, 0.00; D, 0.06; E, 0.10. The emission lines match those at the top of the page, 3727 being at the left, 4861 at the right. Note that the helium line 4686 is much more weakened at mid-eclipse than is the oxygen line 3727, indicating that the latter originates in a large nebulous envelope surrounding the binary.

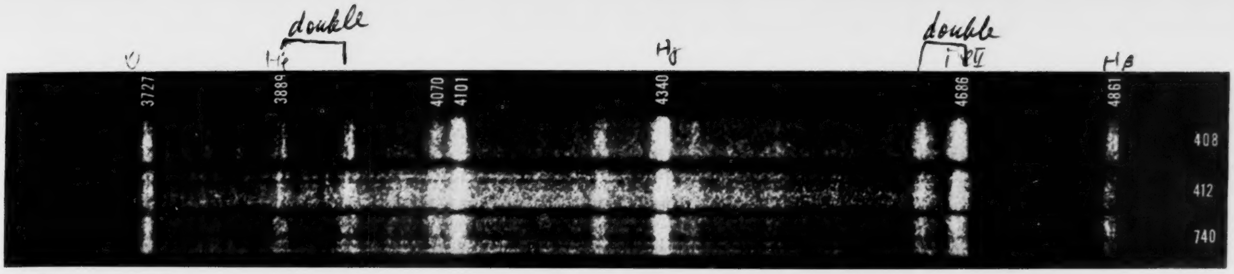


Fig. 5. Spectra at phases 0.32, 0.82, and 0.01, aligned according to wave length, to illustrate radial velocity shifts of the helium 4686 line and the changes in appearance of such double lines as hydrogen-zeta at 3889 angstroms.

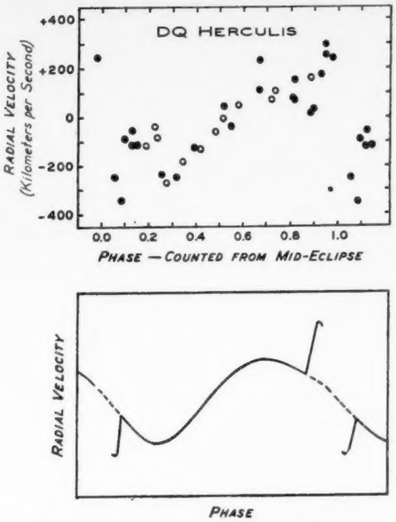


Fig. 6. Radial velocities of DQ Herculis, from spectrum lines of ionized helium. In the upper part, dots are 200-inch observations, open circles 100-inch results. The lower part shows the trend: a sinusoidal variation in velocity, with a marked rotational anomaly superimposed.

"rotational" distortion of the descending part of the velocity curve. At phase 0.9 the 4686 line is gradually shifting more and more toward the violet end of the spectrum, yet it suddenly is displaced toward longer wave lengths by a velocity of recession of about 300 kilometers per second. But this effect is very temporary, for immediately after eclipse the line has a velocity of approach of more than 300 kilometers per second. Thus, the highest and lowest points of the velocity curve occur just before and just after mid-eclipse, respectively. The effect in the spectra is shown in Fig. 7.

This phenomenon resembles one previously found in many other spectroscopic binaries, such as U Cephei and U Sagittae. In the present case, the distortion can be explained by the dark companion star eclipsing a gaseous ring that is revolving around the nova component. The unseen star first passes in front of the approaching half of this ring, so only the receding part is seen. After mid-eclipse the reverse is true, with the receding part covered and the approaching half visible.

The ring is revolving at an average rate of 500 kilometers per second, according to estimates made by Kraft and Greenstein from the total widths of the emission lines produced. The helium 4686 line and the higher members of the Balmer series originate in the ring, whereas an enormous expanding nebulous envelope is mainly responsible for Hβ, Hγ, and forbidden emission lines, such as oxygen 3727. According to M. L. Humason, the velocity of expansion of the envelope is about 300 kilometers per second.

A very rapid, pronounced change in the spectrum of DQ Herculis is recorded in Fig. 7. Kraft and Greenstein describe this event:

"A further strange phenomenon is seen just before mid-eclipse in the He II emission line, and to a lesser extent in some of the hydrogen lines, on plate N 751 only. Exposure N 751b is broken into two parts, one centered at phase about 0.94 P, and one at phase 0.98 P; the latter extends over about five minutes. The last two minutes of this exposure show a very sharp break to the shortward [to the violet] when compared with the first part of the exposure — the break amounts to 890 kilometers per second! Little trace of this effect is seen in Hβ, but it is present to some extent in the higher members of the Balmer series."

A tentative explanation of this phenomenon has been proposed by Kraft, and is illustrated by the accompanying sketch (Fig. 8).

Determining the masses of Nova Herculis and its unseen companion is difficult. If the radial velocity curve of only one component of a spectroscopic binary can be observed — and this is the case for DQ

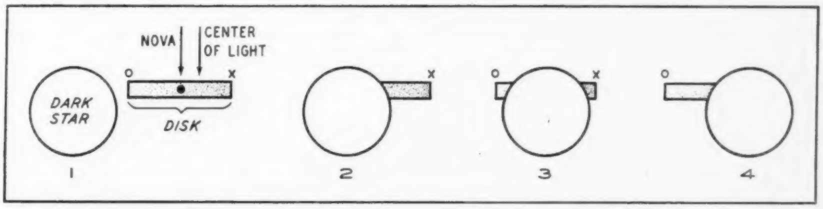


Fig. 8. Four stages in a primary eclipse of DQ Herculis, as interpreted in a sketch by R. P. Kraft. He regards the nebulous appendage of the nova as a disk, rather than a ring. Sketch 1 shows the disk just before it begins to be covered by the dark star. In 2, the nova itself is eclipsed, but the brighter trailing end X of the disk is still seen. In 3, the nova is central behind the dark star, and only the ends of the disk send us light. The rapid change in the helium line 4686, shown in Fig. 7, is explained by the covering up of the receding part X of the disk, so only the approaching end O is observable. This last stage is represented in sketch 4, which also corresponds to the lowest point on the light curve, since O is fainter than X.

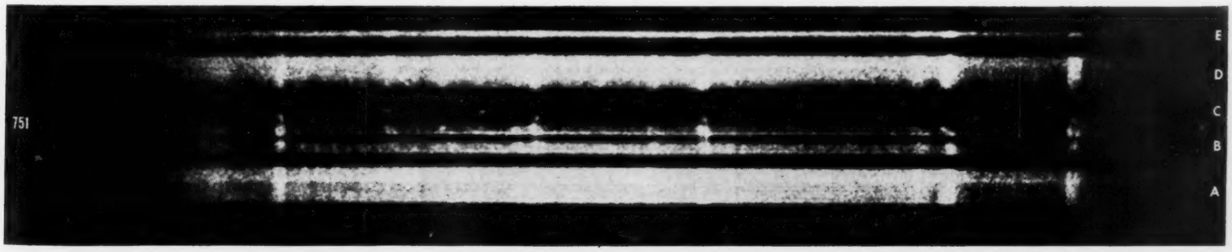


Fig. 7. Exposures taken in the order A to E during a primary eclipse of DQ Herculis, at phases 0.89, 0.95, 0.00, 0.10, and 0.15, respectively. A remarkable change in the helium 4686 line (about $1\frac{1}{2}$ inches from the right end) is seen between the first and second parts of exposure B. Within minutes this line's radial velocity altered by 890 kilometers per second.

Herculis – it is not possible to determine directly the individual masses of the two stars. However, the following table, condensed from the work of Kraft and Greenstein, shows the masses corresponding to several arbitrary values for the mass ratio m_1/m_2. Here the subscript 1 refers to the nova, 2 to its companion.

A mass ratio as small as 0.5 seems quite improbable, as the invisible star would then be twice as massive as the nova. Among binary systems in general, the more massive component is almost without exception the more luminous.

An upper limit to the mass ratio can be inferred from the fact that the nova, with its density of 35,000 grams per cubic centimeter, is essentially a white dwarf star. We know from the theoretical work of S. Chandrasekhar and M. Schönberg that a white dwarf cannot greatly exceed the sun in mass. Hence, the mass ratio 3, which gives the nova more than three solar masses, can be safely excluded. The actual ratio must be near 1 or 2.

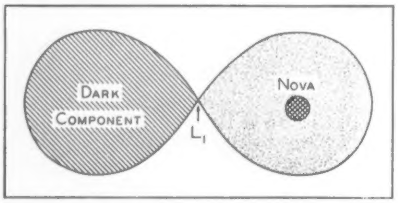


Fig. 9. A schematic view of the zero-velocity surfaces surrounding the two components of DQ Herculis, based on the assumption of equal masses.

The argument can be carried further. If, for example, the nova's mass equaled the sun's (2×10^{33} grams), we would find for its radius about 2.4×10^9 centimeters – only about 1/30 the radius of the sun. The eclipse of so small a star by the invisible companion should be exceedingly rapid, yet Walker's light curves actually show a gradual fading toward mid-eclipse, and a gradual brightening afterward. From this, Kraft argues that the total duration of eclipse as observed by Walker corresponds essentially to the eclipse of the gaseous ring. Moreover, the ring contributes most of the light now observed from DQ Herculis, apart from that originating in the large expanding nebulous envelope.

The gaseous ring probably fills most, if not all, of the zero-velocity surface surrounding the nova. These surfaces, described in detail in the December, 1955, issue, page 64, may be regarded as the boundaries around a binary within which a particle would be permanently retained by the system; a particle outside the zero-velocity surface would tend to escape. In Fig. 9, zero-velocity surfaces have been drawn schematically for equal masses.

Kraft suggests that the invisible star is an *M*-type dwarf that fills its lobe of the zero-velocity surface, and spills some gas through the Lagrangian point L_1 into the lobe surrounding the nova. This gas becomes the ring revolving around the nova at an observed speed of 500 kilometers per second. He then demonstrates that this velocity is dynamically consistent with the assumption that the mass ratio is 1, but inconsistent if it is 2. Therefore, according to the table, the masses of both the nova and its unseen companion are about 0.26 the sun's mass.

Both the radius of the invisible star and that of the outer edge of the gaseous ring turn out to be about 3×10^{10} centimeters. Since the ring is more or less transparent, the observed rotational velocity of 500 kilometers per second does not refer to its outer edge, but to some average distance from the center of the nova, perhaps about 10^{10} centimeters. This is consistent with the requirements of Kepler's third law if the nova's mass is 0.26.

POSSIBLE MODELS OF THE DQ HERCULIS SYSTEM

Assumed mass-ratio (m_1/m_2)	0.5	1.0	2.0	3.0
Orbital velocity (kilometers per second)				
Nova	149	149	149	149
Invisible star	75	149	298	447
Mass (solar units)				
Nova	0.075	0.26	1.19	3.18
Invisible star	0.15	0.26	0.60	1.06
Distance in 10^{10} kilometers of invisible star from center of gravity	2.0	4.0	8.0	12.0

Former Lick Director Dies

THE director of Lick Observatory from 1935 to 1942, William Hammond Wright, passed away on May 16th at San Jose, California. He was 87 years old.

His lifework was the measurement of accurate radial velocities of the stars. The techniques for this had just been developed by W. W. Campbell when Dr. Wright joined the staff at Mt. Hamilton in 1897. In collaboration with Campbell and J. H. Moore, he carried out an enormous program that led to the publication in 1928 of a catalogue of the line-of-sight velocities for all stars brighter than magnitude 5.51.

This project covered the entire sky. Since stars much farther south than declination −20° could not be observed spectrographically with the 36-inch Lick refractor, Dr. Wright led an expedition to Santiago, Chile. There he erected a 36¼-inch reflecting telescope, and between 1903 and 1906 obtained the necessary observations of stars in the southern sky.

W. H. Wright in 1936.

The spectral peculiarities of novae were of major interest to him. For many years, systematic spectrographic records were obtained at Lick of every sufficiently bright nova that appeared.

Widely known was his pioneer photography of the planets in light of different colors, from ultraviolet to infrared. Dr. Wright began such observations of Mars in 1924, and later extended them to Jupiter and other planets. Some examples of his color-filter lunar photographs were reproduced on page 328 of the May, 1958, SKY AND TELESCOPE.

CORRECTIONS

On page 317 of the April issue, the interferometer picture of the solar corona was taken at Atafu during last October's total eclipse by A. H. Jarrett, Observatory of St. Andrews University, Scotland, together with H. von Klüber, University of Cambridge.

S. H. Penny, Jr., Carlsbad, New Mexico, has pointed out an editorial error on page 433 of the June issue. In the table of the decay products of uranium-238, the item $_{83}Pb^{210}$ should read $_{83}Bi^{210}$.

NEWS NOTES

EARTH'S CORE TEMPERATURE

The earth's core is not as hot as previously thought, according to two investigators at the General Electric Research Laboratory, Schenectady, New York.

Dr. Herbert M. Strong and Francis P. Bundy used a hydraulic press, originally designed for manufacturing artificial diamonds, to study variations in the melting point of iron subjected to pressures of up to 1,500,000 pounds per square inch. This is the nearest approximation scientists have yet achieved to the value of 1½ million times atmospheric pressure estimated for the depth of 1,800 miles. There the earth's liquid-iron outer core is assumed to begin. At 3,000 miles down, where the solid-iron inner core begins, the pressure is probably three million atmospheres.

The experimental results were extrapolated to the interior regions, and minimum temperatures were calculated. The outer edge of the molten core at 4,200° Fahrenheit is only slightly cooler than the edge of the solid core, which has a temperature of 4,700°. These results agree with recent studies that indicate the temperature in the earth's mantle does not increase as rapidly inward as first supposed, but independent evidence will be needed to check the validity of the extrapolations.

NONTHERMAL RADIO NOISE FROM JUPITER

In addition to the well-known bursts of low-frequency radio emission from Jupiter, the planet produces steady higher-frequency noise that had been thought to be thermal radiation. From infrared measurements, the black-body temperature of Jupiter is known to be about 120° Kelvin. If the radio flux from the planet is measured at a particular frequency, then it can be calculated what temperature a black body the size of Jupiter must have to provide that flux. For example, several years ago C. Mayer and his colleagues at the Naval Research Laboratory found that Jupiter's radiation of 3-centimeter wave length corresponded to a temperature of 150° K.

On May 5th, at the Washington meeting of the International Scientific Radio Union (URSI) and the Institute of Radio Engineers, F. D. Drake reported new observations upsetting this interpretation. This spring, the flux at 22 centimeters was measured with the 85-foot radio telescope of the National Radio Astronomy Observatory, Green Bank, West Virginia, and was found to imply a Jupiter temperature of 3,000° K.

Clearly, this radiation must be almost entirely nonthermal in origin. Dr. Drake referred to other measurements by H. I. Ewen and himself at 3.75 centimeters, giving 210°; and by R. M. Sloanaker at 10 centimeters, giving about 600°. If the various flux determinations are plotted against frequency on log-log paper, a straight-line relationship is found (after allowing for the 120° thermal flux). Some other cosmic sources are known to give similar straight-line plots, for example the Crab nebula, which is emitting synchrotron radiation.

Dr. Drake suggests that the Jupiter emission is synchrotron radiation originating in Van Allen belts surrounding that planet. On this assumption, the magnetic field of Jupiter would have to be about 10 times stronger than the earth's field, and its Van Allen belts would have to contain about a million times as many charged particles as the earth's belts. Both these assumptions appear physically reasonable. A space traveler landing on Jupiter would face at least 100 times the radiation hazard he encountered on leaving the earth!

Some very recent observations confirm and extend the Green Bank findings. G. Stanley, of California Institute of Technology, has observed Jupiter at a wave length of about 33 centimeters, finding a flux which, were it thermal, would imply a temperature of 10,000° K.

The particle contents of terrestrial Van Allen belts change with time and solar activity. Observations of Jupiter are being continued to ascertain if corresponding changes there reveal themselves by variations in radio flux.

VARIABILITY OF THE SUN

From 1953 to 1958, the sun steadily increased in brightness by 0.03 magnitude, according to H. L. Johnson and B. Iriarte at Lowell Observatory. Their finding resulted from a systematic program of accurate measurements of the light reflected from the planets Uranus and Neptune, in order to detect possible small variations in solar radiation.

It had been known for years that the sun's energy output can change considerably at far-ultraviolet and at radio wave lengths, but this is the first time that the sun has definitely been proved a variable star in visible light. The details of the study, which was supported by the U. S. Air Force, were published in *Bulletin* 96 of the Lowell Observatory.

During the 5½ years beginning January, 1953, a total of 372 photoelectric observations in blue light were made of Uranus, and 264 of Neptune, by six different observers. Each observation consisted of comparisons with two adjacent stars, which were in turn compared with a set of 16 stars of solar type. Thus the average of these 16 stars is the standard against which the sun's constancy was tested, the planets serving only as intermediaries. For the observations, blue light was used instead of yellow, to avoid the methane bands in the planets' atmospheres.

The individual observations were corrected for the changing distances of the planets from the sun and earth, and for phase. In addition, the magnitudes of Uranus were adjusted to correspond to its orientation in 1945, when the polar axis of the oblate planet was pointed toward the earth. The yearly averages are:

Year	*Uranus*	*Neptune*
1952-53	6.070	8.269
1953-54	6.072	8.266
1954-55	6.075	8.251
1955-56	6.056	8.245
1956-57	6.060	8.241
1957-58	6.056	8.235

Each of these is a mean opposition magnitude, that is, the magnitude the planet would have at opposition if at its mean distance from the sun.

The Lowell Observatory astronomers found no indication that either planet was varying in synchronism with its rotation period. Moreover, there was no tendency for Uranus and Neptune to brighten and fade together over a course of consecutive nights, as would have happened had there been short-period solar fluctuations.

To obtain further information about the changing brightness of the sun, Dr. Johnson and his coworkers plan to continue the photoelectric measurements through at least one 11-year cycle of solar activity.

IN THE CURRENT JOURNALS

AN APPLICATION OF SOLAR RADIATION TO SPACE NAVIGATION, by S. James Press, *Solar Energy*, January, 1959. "This study examines the feasibility of determining range in space by means of a passive thermal radiation sensing system. The coordinate system to be employed is heliocentric. Distance from the sun at any instant is measured by analyzing the radiant power impinging on the sensitive elements of a thermal detector sensitive to a slight change in temperature for its response; thermocouples, thermopiles, and bolometers are all in this category."

THE EARTH'S MANTLE, by Gordon G. Lill and Arthur E. Maxwell, *Science*, May 22, 1959. "At present nearly all geophysicists agree that structurally the earth consists of a crust, mantle, core, and inner core. . . . There are several ways to determine the nature of the earth's mantle, but in the last analysis only the direct method will be satisfactory. We must drill down to the mantle and bring up as much sample as possible for examination. We then will know what the mantle is like, at least at that one particular spot."

Photographing the Horizon Eclipse

Not long before the annular phase of the eclipse of the sun on September 1, 1951, Carl A. Wiegold took this horizon view from the airport at Winston-Salem, North Carolina.

IN NEW ENGLAND, totality occurs only a few minutes after sunrise at the solar eclipse of October 2nd, even in the most favored viewing area, along the east coast of Massachusetts. This event will therefore be primarily a spectacle for visual enjoyment and photography, both still and motion picture. Elsewhere along the Atlantic seaboard, the partially eclipsed rising sun will also furnish unusual photographs.

The rapidly changing events that occur at a total eclipse make it difficult to estimate the proper exposures, and the low altitude of the sun on October 2nd further complicates the problem. Now, however, both still and motion-picture cameras are available that have built-in automatically coupled photometers – electric eyes that set aperture or shutter speed or both to the precise light value of the scene. Nevertheless, the fortunate amateur who possesses an electric-eye camera should practice using it, and check in advance its performance under conditions of low illumination.

Only the roughest guide can be given for exposures during totality and for the very thin crescent phases preceding and following it. Previous sunrise eclipses, July 9, 1945, and June 30, 1954, occurred well inland, and most observers did not have to contend with the problems of ocean fog and the smoke of a large metropolitan area such as surrounds Boston. Many factors can affect atmospheric transparency at low altitudes. In general, the problems of photographing the coming eclipse are the same as those for the annular eclipse of September 1, 1951, which began at sunrise near Winston-Salem, North Carolina, and passed off the coast at Norfolk, Virginia.

Some idea of the exposure range involved can be gained from the following figures for the corona when the sun was somewhat higher than it will be on October 2nd during totality. With a film rating of ASA 80, use f/8 at ½ to 1/5 second. For Kodachrome, f/2.8 or faster is required, 1/5 second (on slower cameras, increase the exposure time, but not longer than one second); Kodacolor or regular Anscochrome needs f/3.5 at 1/5 second. Reduce these exposures to one-fourth, or close the iris diaphragm two f/numbers, to capture the "diamond-ring" effect.

For the conditions of this particular eclipse, it will probably be necessary to add at least one stop. However, in eclipse photography it is best to err on the side of underexposure, as it is easier to print faint details on a hard paper than to force an image from a dense negative. If you are in doubt, it is much safer to stop down the lens rather than open it up, provided the difference from a nominal exposure does not exceed 1½ aperture stops.

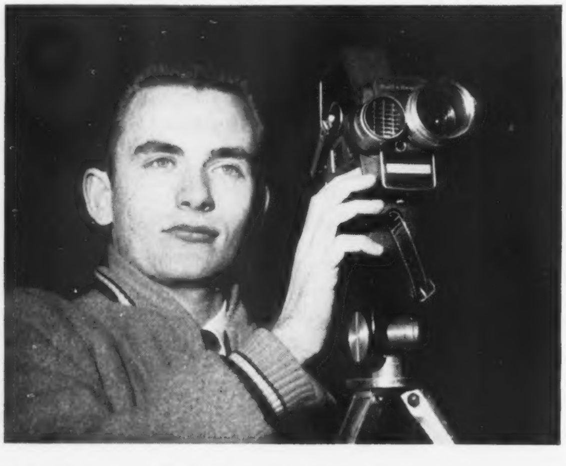
For photography of the partial phases, exposure readings and trial photographs should be made beforehand at the observer's home whenever the sun has the same altitudes that it will have on eclipse morning. You may plan to use the same shutter speed for all the partial phases, changing only the aperture to compensate for the great loss of light near totality. Neutral-density filters are useful.

During the actual total phase, a much slower speed is required. Then the light meter should be pointed directly at the sun. A camera equipped with an iris mechanically coupled to the exposure meter will be easier to operate than one on which the operator must match needle readings. Observers with separate cameras and exposure meters will have to hustle in order to secure a number of shots during the fleeting moments of totality. Be sure to provide for a subdued light with which to illuminate the exposure meter dial and camera setting numbers, as it will be very dark at mid-eclipse.

The sun's proximity to the horizon will permit photography of attractive land scenes or seascapes. But the image of the moon, as it obscures the solar disk, will be only 0.009 the focal length of the lens used, and the resulting size, for ordinary lenses, is about 1/32 to 1/16 inch. Even with a brilliant and extensive corona, it is unlikely that the total size of the image will exceed ¼ inch. Telephoto lenses of standard focal lengths can be used to enlarge the eclipse image, yet will retain interesting foregrounds within the field of view. For adequate-sized images of the eclipse alone, telephotos of great magnification or astronomical telescopes should be used.

Color film will enable photographers to record all of the unusual sky hues that should be present. Probably Kodacolor or Anscochrome regular (both with an ASA rating of 32) will yield the best pictures, giving a minimum of grain to enlargements. High-speed Ektachrome and similar fast color emulsions may not be needed, since considerable illumination spreads in around the slender cone of shadow. Cinematographers, restricted to uniform instantaneous exposures, will find the comparatively moderate rating of Kodachrome satisfactory, unless misty conditions dim totality, in which case Super Anscochrome may be needed.

For black-and-white photographs, a number of moderately slow, fine-grained films are available, especially in the 35-mm. size. Roll-film cameras can use Kodak Verichrome Pan, Adox 17 and 21, but for many roll-film and press cameras 35-mm. adapters are obtainable to make use of some of the other superior emulsions.



Ted Kaplits, of Massapequa, New York, is going to let the automatic diaphragm of a 16-mm. Bell and Howell 240 EE (with electric eye) camera set the exposure when he observes the October 2nd eclipse at Salem, Massachusetts. The camera will also be equipped with a telephoto lens to increase the size of the sun's image. Photograph by Peter A. Leavens.

For cameras with slow lenses (f/4.5), try Kodak Plus X, which works very well at an ASA rating of 160, with development for three minutes in Ethol UFG at 70° Fahrenheit. Two other suitable developers are Ilford Microphen and May and Baker Promicrol.

With fast lenses (f/3.5 or better), the amateur may use a thin-base ultra-fine-grain film. Two of these are Ilford Pan F and Adox KB-17, the first rated at ASA 25, the latter at ASA 40. They give the best results if exposed at 50 and 64, respectively, and developed in one of the special developers designed for thin-base film. Three of the more popular are FR X-22, Agfa Rodinal, and Edwal Concentrate No. 2.

For partial-eclipse pictures, a double-exposure technique will give better contrast between the sun and the foreground than is possible with a single exposure. Just before sunrise, a horizon silhouette is made with a one-stop underexposure, the camera being firmly mounted and aimed. About five or six minutes after sunrise, the crescent is photographed on the same film, its image being slightly overexposed. The camera must not be moved between the exposures.

After totality, for partial phases on the same negative, expose every five minutes, thus spacing the images on the film. Similarly, motion-picture photographers may take time-lapse shots, one frame each second, while guiding on the sun. Roughly, Kodachrome exposures should be about 1/500 second at f/32, with a four-factor (4x) neutral density filter. Film rated ASA 80 should be exposed 1/100 second at f/25, using a 4.0 (not 4x) neutral density filter.

EDITOR'S NOTE: This article is based on data compiled by Peter A. Leavens, Freeport, New York, and Robert E. Cox, Cambridge, Massachusetts.

CORRECTIONS

On page 332 of the April issue, an editorial error was made in the NGC number of M108, which should read 3556.

On page 375 of the May issue, it should have been stated that M3 is 33 minutes of right ascension west (not east) of Arcturus.

These errors were pointed out by Joseph Ross, Bedford, Massachusetts, and C. E. Meermans, Lakewood, Ohio, respectively.

Planetarium Representatives Attend International Conference

RAPID GROWTH of public interest in astronomy has increased the need for planetariums to co-operate in their task of scientific popularization. To share their experiences and ideas, more than 30 officials from 21 planetariums in 10 countries met at the American Museum-Hayden Planetarium in New York City during the week of May 11th (page 368, May issue).

The sessions were in the form of group discussions, each under the direction of a delegate to the conference. Planetarium business operations, and the programs and services that these institutions should offer, were pondered at the session presided over by C. V. Starrett, of the Buhl Planetarium in Pittsburgh. Devices for providing special effects and projection instruments were discussed at another session.

Lectures themselves — both presentation and content — were considered in detail under the leadership of T. D. Nicholson, of New York's Hayden Planetarium.

The final conference in that city dealt with planetariums and the future, Dr. Henry C. King, director of the London Planetarium, acting as chairman. The topics were special courses, lectures, original and applied research, and exhibits, past, present, and future. This program explored the great opportunity planetariums have to extend their mission of public education.

The last three days of the conference were taken up by tours to Philadelphia and Boston, to see the Fels and Charles Hayden planetariums in operation.

From such widely separated places as Moscow, Montevideo, and Los Angeles, these planetarium executives came to the May conference at the American Museum-Hayden Planetarium in New York City.

Front row (left to right):
Mrs. R. Cialdea and daughter; R. Cialdea, Rome, Italy; J. Chamberlain, AMH; H. Auer, Deutsches Museum, Munich, West Germany; Mrs. J. Raimond; F. Branley, AMH; I. Levitt, Fels, Philadelphia; A. Spitz, National, Washington, D. C.; F. Guido, Montevideo, Uruguay; A. Mazza, Sao Paulo, Brazil; H. King, London, England; G. Schwesinger, Carl Zeiss, Oberkochen, West Germany; V. Bazykin, Moscow, U. S. S. R.; K. Franklin, AMH.

Middle row:
Miss Sirini (interpreter); Miss R. Norton, AMH; M. Moore, Longway, Flint, Mich.; R. Phrang, AF; J. Meyer, Hamburg, West Germany; J. Salabun, Copernicus, Chorzow, Poland; Mrs. Bastianello (interpreter); C. Barthel, AF; A. Jenzano, Morehead, Chapel Hill, N. C.; C. Cleminshaw, Griffith, Los Angeles; A. Orsini, Sao Paulo, Brazil; C. Starrett, Buhl, Pittsburgh; J. Patterson, Hayden, Boston; Mr. Khartchenko (interpreter); Miss K. Swift, AMH.

Top row:
T. Nicholson, AMH; J. Raimond, The Hague, Netherlands; F. Ethridge, AF; J. Pickering, AMH; H. Beck, Carl Zeiss, Jena, East Germany; C. Hagar, Morrison, San Francisco; J. Verwer, Buhl, Pittsburgh; J. Tuma, AMH; R. Johnson, Adler, Chicago; R. Adler, Adler, Chicago.

AMH, American Museum-Hayden, New York; AF, United States Air Force Academy, Colorado Springs. To save space, the word "planetarium" has been omitted from the names of the institutions above.

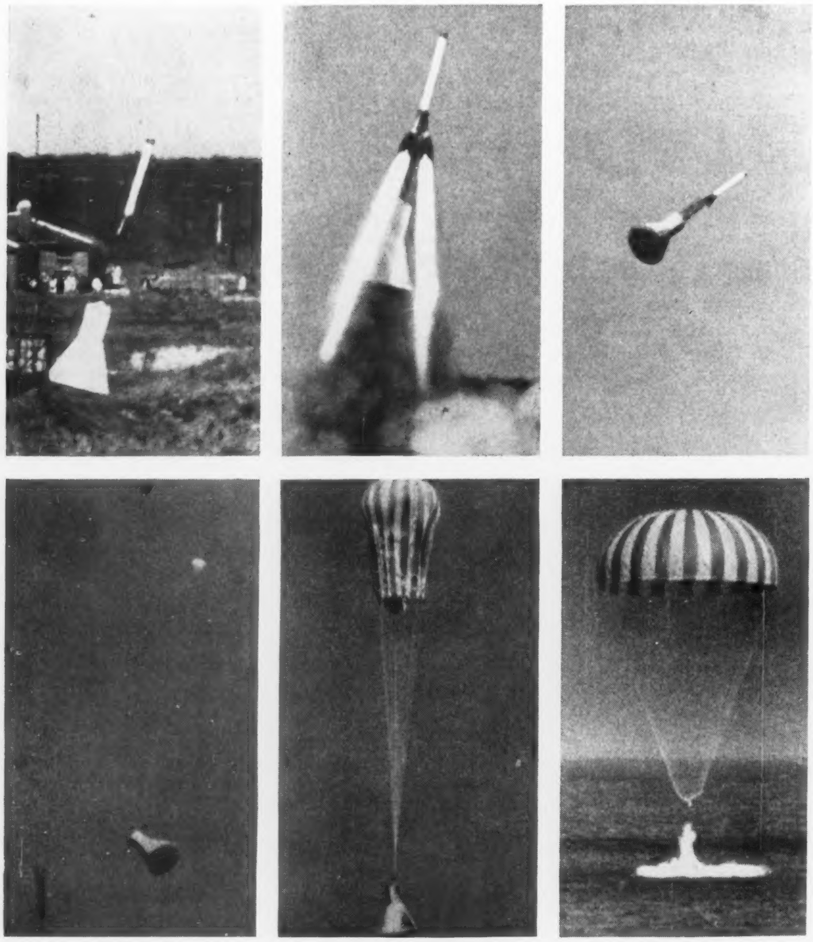
OBSERVING THE SATELLITES

Project Mercury

MANNED SPACEFLIGHT is the goal of extensive collaboration among scientists from many fields who are participating in Project Mercury (page 260, March issue). While the first American may not go aloft for at least a year and a half, some 200 million dollars are now being spent to perfect the man-carrying capsule, to study the fundamental problems of survival in space, to train the astronauts, and to design and build the highly complex tracking and communications network. In addition, the giant Atlas rockets that will carry the payload are undergoing test after test to improve their reliability.

For the National Aeronautics and Space Administration, elaborate studies are being made of the unusual Mercury capsule design and of its accessory equipment. At Langley Research Center, in Virginia, and at other NASA and Air Force stations, wind tunnels are being used to ascertain the aerodynamic behavior of models over a wider range of speeds, up to 20 times that of sound, than any manned aircraft has ever experienced. Full-scale model capsules have been dropped from high-altitude planes to test the parachute assemblies.

To study the escape system, the Pilotless Aircraft Research Station, at Wallops Island, Virginia, is using full-scale "boilerplate" models – mock-ups of the proper shape and weight, but lacking interior details. Of great importance is the proper alignment of the rocket nozzles used to separate the capsule from the booster if something goes wrong during launching. The parachute has been designed to reduce the speed of descent to 30 feet per second, and the capsule must withstand this impact velocity whether it alights on water or land. For the latter, adequate cushioning methods must be developed.



The escape mechanism of the Project Mercury package was tested at Wallops Island last spring. The escape rockets lifted the capsule to 2,250 feet, where the tripod (seen between the rocket exhaust flames) was ejected. First a small parachute and then a large one were released and the capsule descended to the surface of the sea for recovery by helicopter. National Aeronautics and Space Administration photographs.

After the design of the packet has met all these tests, prototype models will be mounted on booster rockets, to study the system under progressively severer stresses. The first such booster is the "Little Joe," a cluster of four Thiokol Sergeant rockets. Later, the cabin will be tested, with animal passengers, on a modified Redstone missile. In another trial, perhaps early in 1960, the Mercury astronauts will be carried by highly reliable Redstones in flights down the Atlantic missile range from Cape Canaveral, Florida, for several hundred miles at suborbital speeds.

For aerodynamic and re-entry properties, an empty capsule will be boosted by Jupiter rockets to speeds exceeding 17,000 miles per hour. Other experiments may employ an Atlas booster in similar flights, some carrying trained chimpanzees to test the life-supporting equipment. Not until the entire Mercury assembly can function reliably by remote control will a man be sent up inside it.

Much fundamental biological information must be gathered before the first manned orbital flight. Little is known about the survival of animals who have actually been launched to high altitudes. One recent literature survey found only six published medical reports, three Russian and three American, concerning the response of mammals in space, although there is much information on simulated conditions.

In an American experiment on May 28th, two monkey passengers flew 1,700 miles in a Jupiter nose cone which reached a 300-mile altitude. The successful recovery of the two simian passengers, Able and Baker, with a variety of other biological specimens, greatly increased our limited knowledge of how living organisms fare in a space environment. The two animals survived well their brief exposure to conditions resembling actual orbiting. Five days later, the seven-pound rhesus monkey, Able, died during an operation, but not from the effects of the flight itself.

During the same rocket ascent, the immense 38-*g* acceleration of re-entry, the weightlessness during the nine minutes of free flight, the vibration, cosmic radiation, and other hazards acted on the biological specimens, which included human blood, sea-urchin eggs for a study of fertilization, and fruit-fly larvae for genetic studies. During the coming year, many other such experiments are planned.

Meanwhile, the training of the seven Project Mercury astronauts is proceeding at Langley Research Center and elsewhere. These selected military test pilots are all of superior intelligence, and high physical and emotional fitness. Part of their time is being devoted to receiving further education in basic sciences from astrophysics to geography, to prepare them for making observations from Mercury capsules. Each of the seven is a qualified engineer, engaged part time in

These fiberglass and plaster molds are designs of the couch which one of the Project Mercury astronauts will ride during manned orbital flight. Inspecting the molds, at Langley Air Force Base, are the seven trainees themselves (left to right): Navy Lt. Comdr. Alan B. Shepard, Jr., Marine Lt. Col. John H. Glenn, Jr., Navy Lt. Comdr. Walter M. Schirra, Jr., Navy Lt. Malcolm S. Carpenter, Air Force Capts. Leroy G. Cooper, Jr., Donald K. Slayton, and Virgil I. Grissom. At the right is Robert R. Gilruth, director of Project Mercury. Photographs on this page are from National Aeronautics and Space Administration.

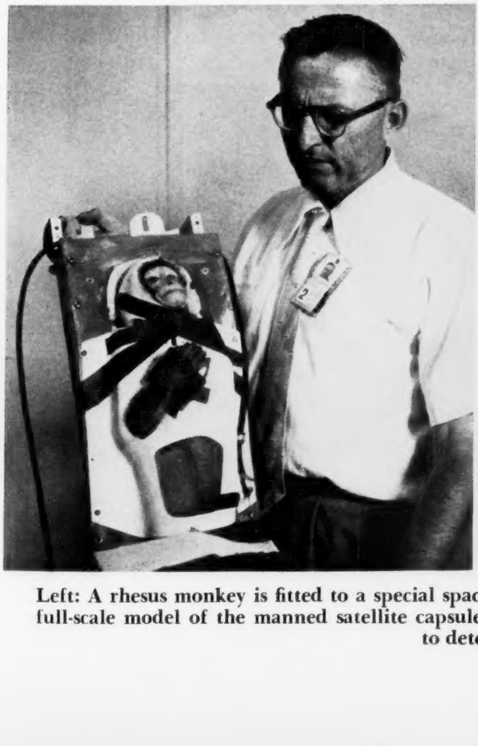
developing some phase of the Mercury system. They will be acclimatized as thoroughly as possible for the heat, pressures, and accelerations they will face in actual flight. Also, they must master the handling of the controls within the Mercury cabin if command signals fail, and they must understand thoroughly the ground support facilities.

During both launching and re-entry, the passenger is to be cushioned in a contoured frame, oriented so that the acceleration force will be directed against his back. It is now believed that the peak acceleration will amount to about nine g's during re-entry, but it may briefly reach as much as 20 g's if it is necessary to escape from a defective booster. Experiments with man-carrying centrifuges have shown that a bent-knee position, with force exerted along the back, provides the least circulatory strain, and allows the subject to have some use of his fingers.

Project Mercury will involve an extensive tracking and communications network. At least 14 major stations, some aboard ocean vessels, will help maintain continuous contact with the manned vehicle. The Atlantic missile range, extending southeastward from Cape Canaveral, will be the safest area for re-entry, and the programming of the entire flight proceeds backward from this consideration. Also, the vehicle should avoid the most intense regions of the inner Van Allen radiation belt, in order to minimize the weight of shielding. An orbiting altitude of 120 to 130 nautical miles has been selected, with a launching direction slightly north of east from Cape Canaveral, providing an orbital inclination of 30 degrees.

Previous launchings from the Florida base have not used this particular direction, so new tracking and communication facilities are needed along the great circle passing north of Bermuda, across the Atlantic and over the northwest corner of Africa. Because of regression of the orbit and the earth's rotation, the beginning of the fourth orbital revolution will lie over the present Atlantic missile range. It is planned to trigger re-entry near the end of the third orbital revolution, over a point some 600 miles west of the California coast, so that the capsule will descend in a gentle arc across North America and land in the Atlantic Ocean about 400 miles southeast of Florida.

During the entire time the astronaut is aloft, the task of the radio network will be exacting. The position of the satellite must be known with unprecedented accuracy. At present, orbital predictions for a new satellite are commonly in error by several minutes of time and several hundred miles during the first day in orbit. In the Mercury experiment, the life of



Left: A rhesus monkey is fitted to a special space suit and helmet for journeying through the upper atmosphere. Right: A full-scale model of the manned satellite capsule is positioned in the wind tunnel of the Langley Research Center, in tests to determine lift, drag, and static stability.

the astronaut depends upon precise early knowledge of not only his position at every moment but his predicted point of impact, should some emergency require premature re-entry.

The new tracking facilities will be linked by direct cable or radio with the Goddard Space Research Center in Washington, D. C. Over-all command of the network will be at Cape Canaveral. Secret frequencies are to be employed for all radio commands, to lessen the chance of unauthorized triggering of any equipment in the satellite.

Recovery of 1958β1

As TOLD on page 320 of the April issue, the rocket carrier of satellite Vanguard I, designated as 1958β1, was lost for more than a year since its launching on March 17, 1958. It has now been found through a concerted search, involving more than three dozen Moonwatch stations, that was planned by K. G. Henize of the Smithsonian Astrophysical Observatory.

The successful observations were made on the evening of May 6th, at a joint session of two Moonwatch teams at Albuquerque, New Mexico, led by K. W. Shaw and Mrs. V. Hefferan. The 7th-magnitude object, traveling eastward at half a degree per second, was seen in the overlapping fields of two 120-mm. apogee telescopes.

With the aid of this information, Arthur S. Leonard made predictions for his Sacramento, California, Moonwatch station, where a passage of 1958β1 was observed on May 10th. This allowed him to calculate improved orbital elements, which were confirmed by sightings the next night at Albuquerque and four California stations, as well as by photographs with Baker-Nunn tracking cameras at Organ Pass, New Mexico, and at Maui, Hawaii.

The period of the rocket is considerably longer than that of the 6-inch radio-carrying sphere, 1958β2. On June 1st the difference in period was about $4\frac{1}{2}$ minutes. Evidently, in this case as well as for Vanguard II, the spherical satellite was ejected before the rocket had consumed all of its fuel.

This is explained by the fact that in a solid-fuel rocket splinters of unburned propellant may remain smoldering for some minutes after the main body has burned out. The continuing gentle emission of exhaust gas could account for the greater speed of the rocket carrier, which at perigee travels about 200 feet per second faster than the sphere.

Now that the orbit of 1958β1 is known, Smithsonian computers have found that a number of last year's observations, previously rejected for large discordances, actually belong to this elusive object.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.

Amateur Astronomers

New Zealand Amateurs Erect Planetarium

THE Nelson Planetarium is an experiment in optics, building construction, demonstration procedure, and economics. The New Zealand enthusiasts who devoted their time and money to the project believe it successful, although the instrument and theater dome have been put away until summer next December.

There is basically no difference between our projector and manufactured ones. It was inspired by the very first such instrument, the Munich planetarium. Readers who are familiar with the German projector will recognize the similarity of the protruding lens systems, the $23\frac{1}{2}$-degree ecliptic axis, and the in-line planetary mechanisms.

The star globe is a 10-inch-diameter glass bowl, illuminated by a 500-candle-power mercury-vapor lamp. It projects 22 star fields through f/1.6 lenses, which were made by Miss P. E. Vause, a health education officer. All projector motions are manually operated, the diurnal control being through an automobile-starter ring gear.

A howitzer-shaped device is employed as a constellation configuration projector, to superimpose line drawings of the principal figures on their respective star images. Latitude can be changed from the equator to the south terrestrial pole through a worm-and-pinion drive.

The planetarium dome, designed by Frank Mosey, is 24 feet in diameter and elevated six feet above the floor. There are 24 three-foot segments made from 1-by-2-inch lumber, supporting more than 1,200 small flat components that make up the hemisphere. It is lined with tar-and-hemp laminated paper, painted white. The reflective surface of this paper is satisfactory, the creases not being intolerable, but precautions must be taken against voice echo.

The mathematical design and mechanical work on the projector were completed by Douglas Mabin and myself. We did not give serious consideration to any other feature until we solved the globe problem.

We have decided that complicated solar-system projectors are not warranted on small and medium amateur instruments. In a future redesign, four planet projectors will be placed on the star globe, two mounted on swivel joints at each ecliptic pole and preset for the particular night in question. A secondary device, separate from the main projector and manually operated, will display the oscillating motion peculiar to the inferior planets and the retrograde motion of the superior planets.

A general observation of audiences attending the first New Zealand planetarium is that they delight in a picture show. Therefore, equal time is given to the planetarium demonstration, the magic-lantern pictures of planetary features, and an imaginary voyage beyond our galaxy in a picture-strip form.

W. M. SWINBURN
203 Haven Rd.
Nelson, New Zealand

SOUTHEAST CONVENTION

NINE societies and six Moonwatch teams from five states were represented by the 72 delegates attending the annual convention of the Southeast Region of the Astronomical League, May 8-10, at the George Washington Hotel,

W. M. Swinburn (right center) demonstrates the Nelson Planetarium projector to some visitors. Note the local landscape background around the chamber horizon. Geoffrey Wood Studios photograph.

Jacksonville, Florida. The Jacksonville Astronomy Club was the host society.

On the first evening, a capacity audience of 1,500 enjoyed a public lecture and motion picture, Through the 200-inch Telescope, presented by Dr. Ruroy Sibley, St. Petersburg. The following morning was devoted to technical talks and a discussion of satellite-tracking procedures.

At the afternoon session Dr. Guy C. Omer, University of Florida, spoke on cosmology, and Mrs. Elizabeth James on dating the crucifixion of Jesus by astronomical means. Banquet speakers were Chandler H. Holton, league president, who reviewed the region's growth, and Dr. Karel Hujer, University of Chattanooga, who talked about the measurement of space.

On exhibition were telescopes ranging from two to eight inches in aperture, celestial cameras and photographs, rocket and satellite models, and a game board for testing astronomical knowledge. The weather was favorable throughout the meeting, and star parties were held each night on the hotel roof.

The following were elected regional officers: John A. Ebel, Gainesville, Fla., chairman; H. R. Hudson, Atlanta, Ga., vice chairman; Robert L. Paine, Decatur, Ga., treasurer; and the undersigned, secretary.

P. O. PARKER
111 N. 13th St.
Griffin, Ga.

SOCIETY LISTING

The October issue is tentatively scheduled to carry Here and There with Amateurs, the compilation of all amateur groups that have registered with SKY AND TELESCOPE. Any changes in the previous listing, beginning on page 325 of the April, 1959, issue, should be sent to this magazine by August 1st. Clubs that were not included there and whose membership and meetings are open to the public should write for a registration blank.

NEW JERSEY STAR PARTIES

The 109 members of the Amateur Astronomers, Inc., of Union County, New Jersey, are holding a series of star parties at Lake Surprise Circle in Watchung Reservation. The group meets at dusk, and visitors are welcome.

Weather permitting, the meetings are on July 10th and 29th, August 12th and 28th, and September 23rd. On July 29th (alternate date, the 30th), K. D. Smith will be discussion leader on meteors and minor planets; August 12th (alternate date, the 13th), Dr. Lewis Thomas on lunar features; September 23rd (alternate date, the 24th), Samuel Mellor on autumn skies.

New officers of the club are: Dr. M. C. Reed, president; K. D. Smith, vice-president; F. Horning, recording secretary; and A. Paone, treasurer. The corresponding secretary is J. W. Kenealy, 16 Rolling Rd., Middlesex, N. J.

NORTH-CENTRAL CONVENTION

THERE were 182 registrants representing 20 societies from three states for the North-Central regional convention of the Astronomical League at Lemont, Illinois, May 23rd. The Argonne Astronomy Club was host.

Before the meeting was convened at the Argonne National Laboratory, two tours of the plant were held, one group visiting the high-energy neutron-producing reactor, the other the experimental boiling-water reactor that provides half of the installation's power.

At the morning session, talks were given by Richard E. Wends on the construction of an astronomical camera with a war-surplus lens, B. Doe on making a simple high-accuracy satellite timer, and H. DaBoll on conducting mirror making classes. After the business meeting, Dr. Ralph C. Huffer, Beloit College, spoke on some current ideas of stellar evolution.

Following a junior session, David D. Morrison, the junior who was chosen to accompany the American expedition to the total solar eclipse in the South Pacific last October, gave an illustrated account of his trip. The convention banquet speaker that evening was Dr. G. C. McVittie, University of Illinois Observatory, who talked on cosmic distances.

Regional officers for the coming year are David G. Kocher, University of Illinois Astronomical Society, chairman; Richard R. Fink, Milwaukee Astronomical Society, vice-chairman; and the undersigned, secretary-treasurer. The 1960 meeting will be held at Madison, Wisconsin.

JOSE HERNANDEZ
529 Mackubin St.
St. Paul 3, Minn.

STELLAFANE MEETING

The 1959 Stellafane convention of amateur telescope makers will be held atop Breezy Hill, Springfield, Vermont, on Saturday, August 8th. The program is being arranged by the Astronomy Section of the Rochester Academy of Sciences. Requests for information should be addressed to George Keene, 76 Westland Ave., Rochester 18, N. Y.

Camping in a nearby pasture will be allowed on Friday and Saturday nights. Reservations for rooms or motels may be made with E. Merryfield, Hartness House, Springfield, Vt.

COLORADO AMATEURS TO INSTRUCT GIRL SCOUTS

The amateur astronomy clubs of Colorado Springs, Denver, and Pueblo will conduct an "Operation Sky-watch" program for the girl scout senior roundup at Colorado Springs, July 3-12. The societies will set up 24 telescopes for stargazing and satellite tracking.

QUESTIONS... FROM THE S+T MAILBAG

Q. What is a great aurora?

A. According to *News Letter* 21 of the IGY Auroral Data Center at Cornell University, it is an auroral display that comes south of geomagnetic latitude 50° north in the eastern United States, or north of 50° south in New Zealand. Great auroras extend over 3,000 miles east-west and about 1,000 miles north-south. Under favorable conditions they can be seen by observers up to a thousand miles away. Each such display is almost always accompanied by a severe magnetic storm.

Q. How long does it take light to reach the earth from Jupiter?

A. Jupiter can be as near as 367 million miles, and as far as 600 million. These distances correspond to light-times of 33 and 54 minutes, respectively.

Q. Which was the first planet discovered?

A. Uranus, found by William Herschel in 1781. The bright planets, Mercury, Venus, Mars, Jupiter, and Saturn, had been known since prehistoric times, and cannot be said to have been "discovered."

Q. How many hours did it take actually to pour the 200-inch mirror blank for the Hale telescope at Palomar?

A. Six hours were required to pour the 20 tons of molten Pyrex glass needed for the disk.

Q. How is it possible to take an astronomical photograph of 24 or more hours exposure time, as is the case with some spectrograms of faint galaxies?

A. The total exposure is made in installments, over several nights. Great care must be used in positioning the plate so that the individual exposures exactly coincide.

Q. What is the total mass of all the asteroids?

A. According to one published estimate, the combined mass of these objects is about 0.0003 that of the earth, or 1/40 the moon's mass, but there is much uncertainty.

W. E. S.

OCCULTATION OF REGULUS BY VENUS THIS MONTH

(Continued from page 483)

G. de Vaucouleurs, Harvard Observatory, has made detailed calculations of the expected light changes of the star, finding that most of the effect will take place within an interval of two to five seconds, both at disappearance and at reappearance. Hence, he points out, an experienced visual observer should be able to note within about one second the moment at which the star has faded to half brightness. Determinations of this sort by amateurs with telescopes of more than about 6-inch aperture would be of scientific value, provided their watches or other timekeepers are checked against radio time signals.

AT LAST!

The Book Every Amateur Has Been Seeking

"HOW TO USE YOUR TELESCOPE"

A down-to-earth introduction to astronomical telescopes and the stars — ideal for the beginner and full of useful information for any amateur. In clear, simple language, profusely illustrated, nontechnical. You'll refer to this booklet often and will rate it a "must." Features moon map, sky show, diagrams, selected sky objects, and the like. It tells you things you should know about astronomical telescopes — selecting your telescope, power, light gathering, field of view, telescope performance — what to expect, how to use your telescope, what eyepiece is best, equatorial mounts — how to use, collimation and adjustments, Barlow lenses (power boosters). Learn about observing the planets, comparing the planets, observing the sun, finding sky objects, astronomical photography with your telescope, splitting double stars, Dawes' limit, telescope arithmetic, sky sweeping.

Stock #9055-Y . . . 32 pages, 8½" x 11" . . . **only 60c ppd.**

"TIME IN ASTRONOMY" BOOKLET

By Sam Brown. All about various kinds of time, contains sidereal timetable. How to use single- and double-index setting circles, how to adjust an equatorial mount, list of sky objects. Also includes 7" paper setting circles and stripes suitable for cutting out and mounting on plywood. Wonderfully illustrated.

Stock #9054-Y . . . . **60c ppd.**

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ASTRO COMPASS and STAR FINDER

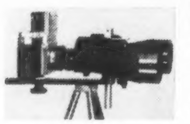
Gov't. Cost $75 — Price $14.95 ppd.

Determines positions of stars quickly. Shows various celestial co-ordinates. An extremely useful star finder which can be rotated through 60° angles along calibrated degree scale. Has single eye lens with viewing stop, two spirit levels for aligning, tangent screw with scale for five precision readings, azimuth scale graduated in two-degree intervals, adjustable tilting azimuth scale for angle reference of stars on distant objects. War surplus. Gov't. cost $75. Instructions, carrying case included.

Stock #70,200-Y . . . . **Only $14.95 ppd.**

NEW BINOCULAR-TO-CAMERA HOLDER

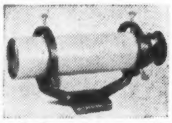
For Exciting Telephoto Shots



Bring distant objects 7 times nearer with a 35-mm. camera, 7 x 50 binocular, and our NEW BINOCULAR-TO-CAMERA HOLDER. Ideal for photographing the coming October eclipse of the sun, star clusters, the moon, as well as cloud formations, wild life, vistas. Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephotos included.

Stock #70,223-Y . . . . **$11.50 ppd.**

DE LUXE FINDER TELESCOPE



Here is a de luxe finder that is very impressive. The telescope part is our regular 5.5-power Moonwatch satellite scope with crosshairs added. The exceptionally large 12° field plus its excellent light-gathering power make this an excellent finder telescope. In addition, you can always take it off for satellite viewing. Twin-ring finder mount is included and makes it easy to center the scope. Can be mounted on tubes of various sizes.

Stock #70,175-Y . . . . **$32.50 ppd.**

TELESCOPE ROLL-FILM CAMERA

This model uses rolls of #127 film. Picture area will be a circle 1-9/16" in diameter.

The advantage of this model is the ease of using roll film. With each camera you get a piece of ground glass. Before loading film in the camera, you focus the telescope. Then lock it in this position. For positions other than infinity, you can scribe a mark on your tube.

Stock #70,182-Y . . . . **$29.50 ppd.**
Stock #70,166-Y . . . . . . **Plate camera** . . . . . . **$39.50 ppd.**

AERIAL CAMERA LENS

f/2.5 with 7" Focal Length

An excellent lens — can be adapted for use on 35-mm. and Speed Graphic cameras as a telephoto lens. Three of the first four pictures of Sputnik III were taken by a student with a homemade camera using one of these lenses. Adjustable diaphragm, f/16 to f/2.5. Gov't. cost over $400. War surplus.

Stock #70,161-Y . . . . **$39.95 ppd.**

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y . . . . **¼" focal length** . . . . **$4.75 ppd.**
Stock #30,203-Y . . . . **½" focal length** . . . . **$4.50 ppd.**

ASTRONOMICAL TELESCOPE MIRRORS

Polished, Aluminized, and Over-coated

SPHERICAL MIRRORS

No.	Diam.	F.L.	Thickness	Price
30,219-Y	3"	18"	⅜"	$5.95 ppd.
50,082-Y	3"	30"	⅜"	7.65 ppd.
50,051-Y	4¼"	45"	⅝"	15.00 ppd.
70,168-Y	6"	72" (Pyrex)	1"	30.00 ppd.

PARABOLIC MIRRORS (Pyrex)

No.	Diam.	F.L.	Thickness	Price
5002-Y	6"	48"	1"	$59.50 ppd.
85,069-Y	8"	64"	1⅜"	89.00 f.o.b.*
85,070-Y	10"	80"	1¾"	179.00 f.o.b.*
85,071-Y	12½"	100"	2⅛"	275.00 f.o.b.*

*f.o.b. Barrington, N. J.

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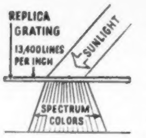

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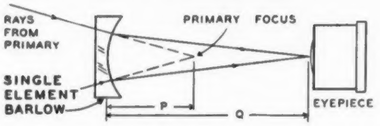
Stock #50,202-Y . . . . Includes 2 pieces, 8" x 5½" — 1 transmission type, 1 reflection type . . . . **$2.00 ppd.**

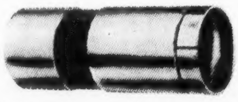
Stock #50,180-Y . . . . 1 piece, transmission type, 8 in. x 6 ft. . . . . **$5.95 ppd.**

Stock #50,203-Y . . . . 1 piece, reflection type, 8 in. x 6 ft. . . . . **$10.95 ppd.**

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Stock #30,200-Y Mounted Barlow lens . . . . . . **$8.00 ppd.**

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length −1-5/16", unmounted.

Stock #30,185-Y . . . . **0.932" diam.** . . . . **$3.50 ppd.**
Stock #30,328-Y . . . . **0.912" diam.** . . . . **$2.50 ppd.**

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Stock #50,074-Y . . . . **$16.25 ppd.**

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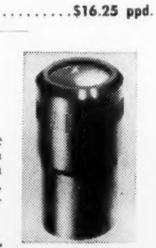


Mounted Kellner Eyepiece, Type 3. Two achromats, focal length 28 mm., eye relief 22 mm. An extension added. O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y . . . . . . **$7.95 ppd.**

EDMUND SCIENTIFIC CO.

OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

LUNAR AND PLANETARY PHOTOGRAPHY WITH A 12½-INCH REFLECTOR

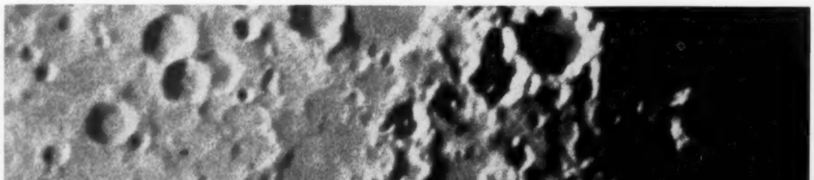
IT IS POSSIBLE to do really first-class photography of the moon and planets with medium-sized instruments, as the pictures here and on the front cover demonstrate. They were all taken with my 12½-inch Newtonian reflector, using eyepiece projection. A great advantage of the reflector in astrophotography is that it does not need to be refocused for each different color filter.

The camera is simply a light-tight box with a shutter near the eyepiece and a plateholder at the other end. It was designed with the help of Elmer Cox. The telescope is f/7.6, and with a 28-mm. eyepiece gives an effective focal length of about 65 feet; this is increased to 109 feet when a 16.8-mm. ocular is used to project the image.

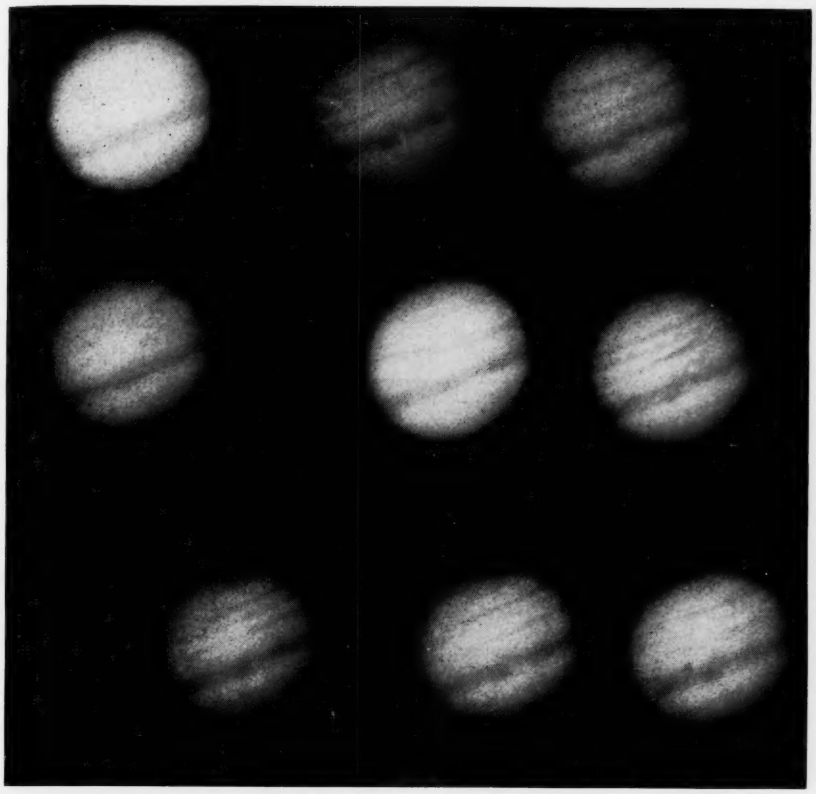
Although the characteristics of Kodak Tri-X and Royal Pan films are very similar, I have had the best luck with the latter. Royal Pan has a more uniform sensitivity throughout the spectrum and appears to give better contrast and resolution. It is especially good when developed in DK-60a. In addition, this film is fairly inexpensive, quite fast, and sufficiently fine-grained. A good trick for the planets is to squeeze as many images as possible on a sheet of film and vary the exposures slightly, so there is a better chance of securing at least one good picture. I have seen some amateurs shoot only one image per sheet of film — this can be rather expensive!

While exposure times for the moon and planets can be determined from formulas, these involve quantities that often have to be guessed at anyway, and I find the "guess-and-press" technique works rather well. Good exposures are half a second on the moon, one second for Jupiter and Mars (the latter with Wratten filter No. 25), and three to five seconds for Saturn. I seldom use filters, however, except for special work.

My interest in astronomy is of long standing, and the 12½-inch is the latest of a series of instruments which began with a 1½-inch. The Newtonian weighs over 2,000 pounds and took six months to



The central portion of the moon, photographed on January 17, 1959, at 5:25 UT, by Jack Eastman with his 12½-inch reflector at f/65. The sun's colongitude was 2°.8. Just below center, Albategnius has a sharp central peak casting a triangular shadow. At bottom center is Hipparchus, a very large crater with low, ruined walls. Along the terminator is Ptolemaeus, mostly in shadow, sunlight grazing its floor and just touching its eastern rim. This crater lies just to the right of the other two and is 93 miles in diameter.

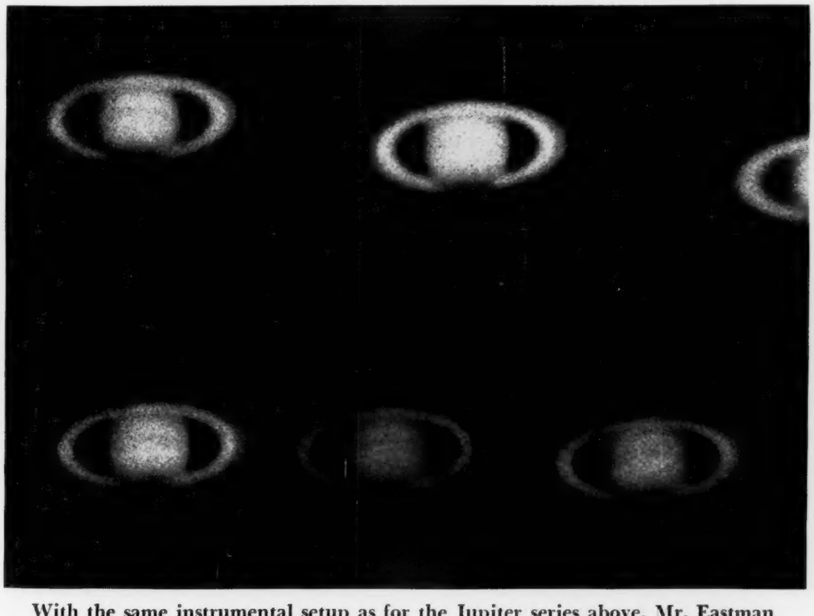


The beautifully banded markings of Jupiter are well shown on these four-time enlargements of a negative made May 21, 1958, at 4:30 UT. All are one-second exposures. The 12½-inch reflector was used with a 145x eyepiece, the effective focal ratio being f/109. Seeing was good, 8 on a scale of 0 to 10.

build, costing $200. It has an electric clock drive and, for guiding, a 4-inch f/22 reflector.

Besides doing astrophotography, I keep a daily record of sunspots with a 2½-inch telescope. I am a member of the Los Angeles Astronomical Society, the Association of Lunar and Planetary Observers, and the local Moonwatch team.

JACK EASTMAN
747 26th St.
Manhattan Beach, Calif.



With the same instrumental setup as for the Jupiter series above, Mr. Eastman photographed Saturn on May 25, 1958, at 9:30 UT. The four-second exposures, enlarged five times, show the effects of variations in the seeing.

Solar Halo Observed in Northeast

An unusually brilliant solar halo attracted widespread attention in the northeastern states for several hours on May 26, 1959. It was noteworthy for the vividness of its coloring, the inner edge of the ring being seen as a bright orange red.

Because the radius of such a halo is 22 degrees, photography of the complete ring was best with a wide-field lens, as was used for this picture by Robert E. Cox. When it was taken, however, the high-level cirrus clouds producing the phenomenon were partly obscured by lower clouds, thereby impairing the uniformity of the ring.

At Eastchester, New York, James E. Striker made two detailed color drawings of the spectacle.

Solar halos of 22-degree radius are caused by refraction of light in prismatic ice crystals of cirrus clouds. Though seldom this bright, as many as 200 halos a year have been recorded by single observers who keep a systematic watch in favorable localities.

The solar halo of May 26th, photographed at 11:47 a.m. EST by Robert E. Cox, Cambridge, Massachusetts. The sun is hidden behind the top of the pole. This is a 1/400-second exposure at f/32 on Royal Pan film, with a Schneider Xenar lens of 3-inch focus, on a 4-by-5-inch Speed Graphic camera.

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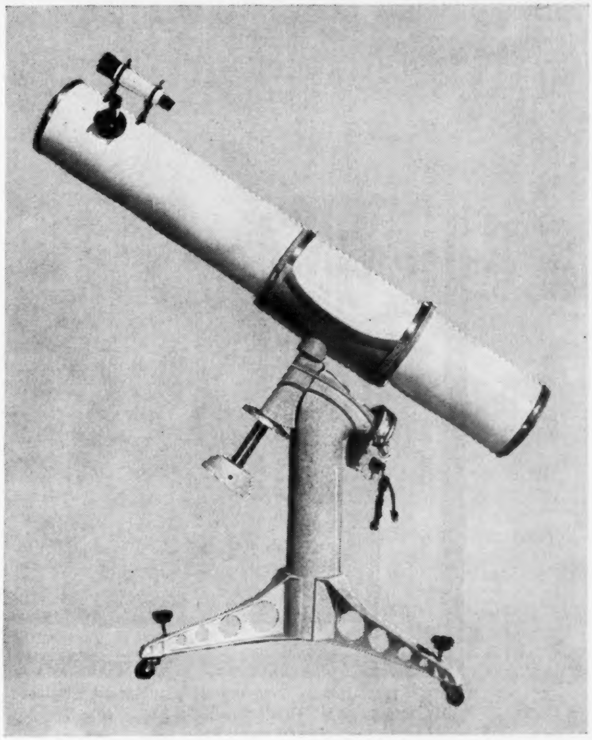

SHOWN ABOVE IS THE 8" DELUXE TRECKERSCOPE

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TRECKERSCOPE optical systems, NOW 1/20th wave, provide very fine viewing at any observing time, and on nights of best seeing give the ability of detecting minute lunar and planetary detail formerly only observable in telescopes of much higher price. Our own Coast Instrument mirrors, in all TRECKERSCOPES, are figured by one of the finest opticians in the world, and we invite any comparative test that is desired to prove that TRECKERSCOPE optics are, beyond shadow of doubt, of incomparably precise quality. Your selection of oculars, from our large stock, allows you to have exactly what you desire in the power range, by means of any three of our standard, orthoscopic ORTHO-STAR eyepieces, available in 6.6-mm., 10-mm., 16-mm., 20-mm., and 26.6-mm. focal lengths, or two of these superb oculars and the famous GOODWIN RESOLVING POWER (Barlow-type) LENS, which provides a wide variety of powers. All telescopes are star-tested before leaving our plant and are guaranteed to resolve to Dawes' limit. While most viewing will be done at relatively low powers, TRECKERSCOPES allow unbelievably high maximum power ranges, due to their 1/20-wave primaries, in excess of 500x in the 6", 650x in the 8", 800x in the 10", and 1,000x in the 12½", when viewing conditions are excellent.

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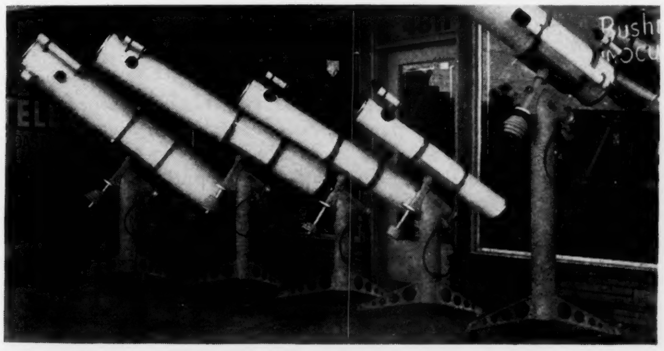

TRECKERSCOPES (from left to right) — 12½" DELUXE, 10" DELUXE, 8" DELUXE, 6" DELUXE, and 10" CASSEGRAIN "SKY-GIANT"

Clock drive, setting circles accurate to 0.001 inch, fully rotating tube saddle assemblies, together with special contoured legs with casters for ease in moving the telescope from storage to viewing position (casters are snapped out when viewing), are all included in the deluxe TRECKERSCOPE models. Standard and deluxe models are otherwise identical as to mount and optical systems, and all deluxe accessories may be added to standard models whenever desired.

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8"	399.50	599.50
10"	675.00	875.00
12½"	995.00	1,195.00

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SLIGHTLY west of the moon's central meridian is the curious formation Cassini, on the western border of Mare Imbrium. Sunrise and sunset occur there only a few hours before first and last quarter, respectively, making this crater a conspicuous object. Under higher solar illumination, it presents little contrast against the surrounding plain, and is nearly invisible at full moon. Perhaps it is for this reason that Cassini was omitted in the 17th-century maps of Hevelius and Riccioli. (The latter chart was reproduced on page 202, February issue.)

When foreshortening is allowed for, the ring plain Cassini is nearly circular, 36 miles in diameter, but with a definite suggestion of polygonal structure. The fairly complete walls are rather low, attaining 4,000 feet only in the west. The crests of the ramparts are narrow. The interior faces look as if they drop steeply to the floor, but the inner wall slope is only 14 degrees in the west and 15-22 degrees in the east, according to P. Fauth. At times the floor has appeared to me to be higher than the surrounding plain. Many terraces and ravines cross the broad outer slopes, which descend irregularly to the plain.

Though the floor of Cassini is relatively smooth, it contains some interesting detail. The largest interior craterlet is Cassini A, 11 miles in diameter and 6,900 feet deep. Inside of it is a small, shallow depression with a deep central pit, aptly called "the washbowl" by its discoverers, H. P. Wilkins and P. Moore. While that feature is not visible in small telescopes, there are other, easily seen details in Cassini A. A prominent ridge crossing the western half of its floor has sometimes been erroneously reported as a central peak.

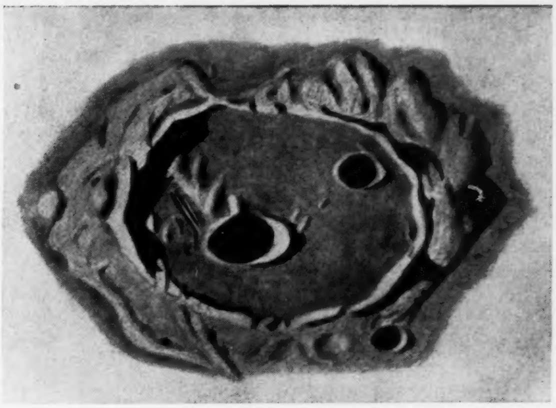
Inside the southeast wall of Cassini is the craterlet Cassini B, 5.8 miles in diameter, with some very low hills between it and A. There is a third craterlet, less than three miles across, located on the floor of Cassini at the foot of its northern wall. It was not seen when this drawing was made, but is not difficult to find under higher illumination.

Note the prominent ridge extending from A almost to the southwest wall of Cassini. Connected to the eastern flank of this ridge is a series of curious curved spurlike appendages, which at times look like the ruined walls of small craterlets.

Parallel to the ridge, on its west, are two rather conspicuous cleftlike valleys, which led me to make this drawing. I had not seen them previously, and could find little published information about them. T. Elger's and W. Goodacre's books do not mention these features, and Wilkins makes only a vague reference to ridges in this area. However, on this occasion, they did look very cleftlike to me, and my further observations confirm this.

Cassini, when seen under the slanting rays of the rising sun, is a most curious object, compared by A. C. Larrieu to "a medieval castle with towers and dungeons." To my fancy, the crater seems to resemble a ghostly ship, forever sailing serenely over the placid waters of the Sea of Showers.

ALIKA K. HERRING
1312 Arlington Ave.
Anaheim, Calif.



A drawing of the lunar crater Cassini, made by Alika K. Herring on July 24, 1958, at 4:30 UT, using 228 power on his 12½-inch reflector. The solar colongitude was 5°.6, the rising sun being at an altitude of 6°.8 on this part of the moon. South is above, west to the left.

MAY AURORA

A COLORFUL display of northern lights provided several hours of interesting observing for viewers in the northeastern United States on the evening of May 4th.

About 8:22 p.m. Eastern standard time, Kenneth J. Delano at Baltimore, Mary-

land, noticed a segment of faint homogeneous arc in the north-northeast, and estimated its altitude as 15 degrees. By 8:35 it had risen to some 30 degrees and was bright in the north. At 10:10 it rapidly changed to a rayed arc, the display being at its peak from then to 10:35. At that time the rays, which extended 38 degrees high, had a greenish white base and red tips. Later the display waned, and at 11:45 there was only a faint horizontal arc very low in the north.

David Czarick of Pottstown, Pennsylvania, recorded red and light green as the colors of the rays, which were estimated by Herbert Luft, Oakland Gardens, New York, to reach an altitude of 50 degrees at 11:00 to 11:30 p.m. EST.

An unusual feature reported by Arden J. Hartzler, Hummelstown, Pennsylvania, was a luminous "cloud" in Auriga, at about 8:35 p.m. EST. It moved steadily eastward, passing between the Big and Little Dippers, and disappeared over the eastern horizon five minutes later. The formation looked "somewhat like a sack with the closed end trailing." For some time after it passed, its trail remained faintly visible.

Michael Bolduan, who observed at Williamstown, Massachusetts, noticed three faint patches of light in the southern sky that united to form a narrow arc extending from the eastern horizon to the western. Pulsating in brightness, the arc moved southward until it was only 30 or 35 degrees above the southern horizon, at about 8:45 p.m. Meanwhile, marked auroral activity was developing in the north, persisting to at least 11 o'clock.

Two New York City amateurs, Milton Jacobs and Barry Gutradt, secured photographs of the display during its peak. They noted a large red ray in the east which lasted some time.

SUNSPOT NUMBERS

The following American sunspot numbers for April have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

April 1, 200; **2,** 177; **3,** 143; **4,** 110; **5,** 107; **6,** 104; **7,** 107; **8,** 139; **9,** 163; **10,** 191; **11,** 195; **12,** 189; **13,** 176; **14,** 168; **15,** 163; **16,** 134; **17,** 128; **18,** 118; **19,** 118; **20,** 135; **21,** 128; **22,** 151; **23,** 153; **24,** 138; **25,** 160; **26,** 183; **27,** 178; **28,** 185; **29,** 131; **30,** 139. Mean for April, 150.4.

Below are mean relative sunspot numbers for May by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

May 1, 108; **2,** 112; **3,** 113; **4,** 105; **5,** 96; **6,** 138; **7,** 156; **8,** 188; **9,** 252; **10,** 268; **11,** 295; **12,** 285; **13,** 265; **14,** 240; **15,** 204; **16,** 182; **17,** 187; **18,** 198; **19,** 185; **20,** 187; **21,** 151; **22,** 145; **23,** 149; **24,** 143; **25,** 178; **26,** 188; **27,** 177; **28,** 132; **29,** 99; **30,** 106; **31,** 130. Mean for May, 173.0.

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ASTROLA MODEL "A", 6-inch, f/7 or f/8	$325.00	$500.00
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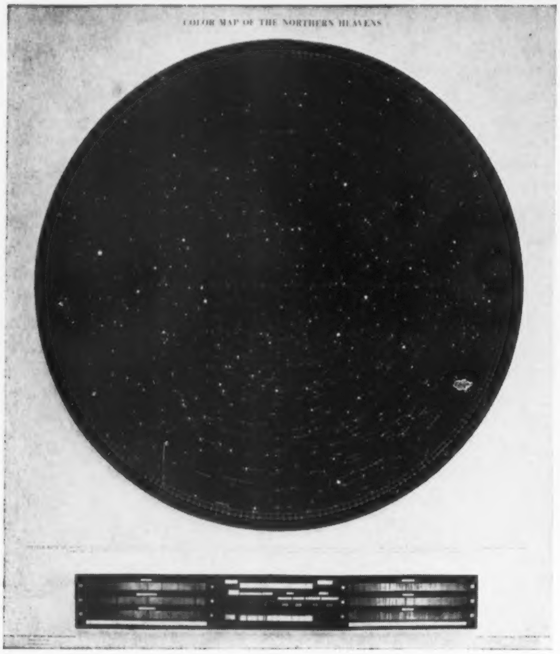
Sky PUBLICATIONS for every astronomical interest



COLOR MAP OF THE NORTHERN HEAVENS

Here is a large wall chart, 30 by 34½ inches, that is colorful as well as informative. The northern sky to −45° is shown on a polar projection, and each star is colored according to its spectral class. Stars brighter than magnitude 5.1 are included. Makes an ideal gift. The map is mailed unfolded in a heavy tube.

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By Antonin Becvar

A bound set of 32 star charts, each 17½ by 24 inches, covers declinations between +30° and −30°, complete to magnitude 9.0, scale two centimeters per degree, epoch 1950.0. Spectral classes are shown by color. See page 161 of the January, 1959, issue for further description. Place your order with us and allow time for its transmission to the publisher in Czechoslovakia, from whom the atlas will be shipped directly to you. **$17.00**

MAKING YOUR OWN TELESCOPE

By Allyn J. Thompson

Here are complete step-by-step directions for making and mounting your own 6-inch reflecting telescope at low cost. The easy-to-understand chapters tell you how to grind, polish, and figure the mirror, and how to make a sturdy equatorial mount to support it.
211 pages, 104 illustrations (6th printing) **$4.00**

Spaceflight

This popular yet authoritative magazine on rockets, astronautics, and space-travel astronomy is written especially for the layman, and is edited by the British Interplanetary Society. Such topics as rocketry, space medicine, atomic fuels, the exploration of the planets, and artificial satellites, are treated nontechnically.

Spaceflight is printed during January, April, July, and October. Please specify the issue with which your subscription should start. Back issues to Vol. 1, No. 1, October, 1956, are available.

Subscription in United States and possessions, Canada, Mexico, and Central and South America: $2.50, four issues; $4.50, eight issues; $6.00, twelve issues. Single copy, 75 cents.

COLOR CHARTS OF THE MOON

Two striking color charts of the first- and last-quarter moon were drawn by Joseph Klepesta, the well-known Czechoslovakian amateur astronomer. Each lunar half is an impressive 27 inches in diameter; the over-all size of a chart, 23 inches wide by 33 inches high. Printed in predominantly gold and black on heavy paper, the charts are shipped unfolded in a cardboard tube. **$3.00 per set of 2**

POPULAR STAR ATLAS

This compact, well-bound set of 16 maps is a simpler version of Norton's *Star Atlas* (temporarily out of stock). All stars down to magnitude 5½ are included. This edition is excellent for field use by constellation study groups and by meteor parties. **$2.00**

Elger's MAP OF THE MOON

The detailed chart of the moon itself is 18 inches in diameter and identifies all the important lunar features. Below the map are notes by H. P. Wilkins on 146 of the more interesting areas. Printed on a sheet of paper 30 by 19½ inches and mounted on heavy canvas, the map is ideal for framing. **$3.00**

MOON SETS

18 pictures, showing the entire visible face of the moon, are made from unsurpassed Lick Observatory negatives of the first and last quarters. Each halftone print is 8½ by 11¾ inches. Key charts supplied. **$3.00 per set**

LUNAR CRESCENT SETS

10 pictures are a matching series to Moon Sets, but for the waxing crescent 4½ days after new moon, and the waning crescent about five days before new moon. Four prints are close-ups of the waxing crescent, four of the waning; two show each crescent as a whole. Key charts included. **$2.50 per set**

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24 pictures of objects in the solar system and in the Milky Way, all celestial wonders of interest and beauty. Each halftone print is 8½ by 11¾ inches. Separate sheet of captions included. Suitable for study or framing for exhibition. **$4.00 per set**

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24 pictures of nebulae in our galaxy, portraits of other galaxies, many made with the 200-inch telescope, including four drawings of that instrument by Russell W. Porter. Sheet of captions included. **$4.00 per set**

LUNAR MAP. In two colors and over 10 inches in diameter. **25 cents each; 3 or more, 20 cents each**

SPLENDORS OF THE SKY. 36-page picture book of our neighbors, near and distant, in the universe. **75c**

RELATIVITY AND ITS ASTRONOMICAL IMPLICATIONS, by Dr. Philipp Frank. **75c**

HOW TO BUILD A QUARTZ MONOCHROMATOR for Observing Prominences on the Sun, by Richard B. Dunn. **50c**

THE STORY OF COSMIC RAYS, by Dr. W. F. G. Swann, Bartol Research Foundation. **75c**

SOUTHERN HEMISPHERE CONSTELLATIONS, by Sir William Peck. 12 monthly maps for latitude −40°. **$2.50**

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Write for descriptive catalogue.

SKY PUBLISHING CORPORATION
Harvard Observatory Cambridge 38, Massachusetts

BOOKS AND THE SKY

HANDBOOK FOR OBSERVING THE SATELLITES

Neale E. Howard. Thomas Y. Crowell Co., New York, 1958. 136 pages. $2.50.

WITH the growing interest in artificial satellites and the difficulties which many of us experienced in the early days of trying to sight them, this book is welcome. It is written specifically for those who want to see and track these man-made objects.

The first chapter presents an especially well-done account of the fundamentals of celestial mechanics. It shows quite clearly why we can see the satellites at certain times and in certain directions, and not at others. It even deals with perturbations and explains the more important effects of atmospheric drag.

Four different methods of predicting the time and position for a satellite's appearance in the sky are given in considerable detail. Since the book was written, however, the Smithsonian Astrophysical Observatory has changed the form of the predictions sent to Moonwatch teams. Specific instructions for using this new form could not, therefore, be included by the author.

Two chapters deal with observing aids. There is a list of important criteria in the selection of a pair of binoculars, and detailed instructions for constructing a standard 2-inch Moonwatch telescope are given.

The satellite-tracking program is explained in some detail, and the usual methods of making observations and recording the time of passages are described.

Moonwatch operations can be divided into three periods — acquisition, tracking, and satellite fall-in. For the first, the entire team, along with telescopes and timing equipment, is employed. For tracking, only a few observers and instruments are required for each observation. In the "dying-moments" period, the telescopes are not used because the object glows from the heat generated by its passage through the denser atmosphere, and direct viewing is adequate.

The naked-eye satellites can be photographed quite easily with many present-day cameras. Detailed instructions are given for obtaining photographs that are scientifically useful. Since pictures offer more accurate observations than visual sightings, great care should be exercised to secure accurate timing.

The final two chapters in the *Handbook* cover the scientific uses of artificial satellites — what they can and have contributed to our knowledge in general, and space travel in particular — and what the future holds for man in his conquest of space. The appendices contain a rather complete glossary of satellite-observing terms, tables of times of twilight, radio time-signal information, and the like. The entire book is well illustrated with drawings and photographs.

For the new observer who wants to understand basic observational problems and the mechanics of satellite motion, this book is valuable. The chapter on orbits may help even the veteran Moonwatcher. The instruments and methods described are applicable to naked-eye satellites. Under the most favorable conditions, they might provide an occasional glimpse of some of the fainter objects; but they will be of little help to a Moonwatch team leader.

Most of the questionable points of the *Handbook* are popular misconceptions. One is that many observers in the United States are located too far north to be able to see American satellites. An example is given on page 17 of an object with an inclination of 35 degrees. It is said that if the satellite happened to be at apogee at the northernmost part of its orbit, persons at the latitude of Buffalo, New York, would see it low in the sky; if at perigee, it would never appear above the horizon. A little trigonometry shows that the object would have to be lower than about 40 miles above the earth's surface to be below the horizon. Admittedly, there is

little prospect of a northern United States observer seeing the fall-in of such a satellite, but given the right telescope he should be able to pick up all of the American moonlets now in orbit.

The concept on page 69 that the "death watch" of a satellite should be maintained all night and in all directions needs correcting. This method is used only if the orbital inclination and the position of the satellite's ascending node are unknown. When the orbital elements are determined, the watch can be reduced usually to an hour or two; and at any particular instant it need cover only a moderately wide band of the sky.

Often repeated in current literature and found here on page 111 is the idea that all we have to do to reach the moon is to get a little past the "neutral point" between it and the earth. Although an object so placed will be attracted toward the moon for a short time, long before it has gained enough velocity toward the target, the moon and the neutral point will have moved away and the earth's attraction will again predominate, causing the object to fall back.

The statement on page 112 that a lunar rocket is liable to orbit the moon a few times and then fly off into space is incorrect.

ARTHUR S. LEONARD
Sacramento, Calif.

THE NINE PLANETS

Franklyn M. Branley. Thomas Y. Crowell Co., New York, 1958. 78 pages. $3.00.

AMONG the many recent books that try to satisfy young people's thirst for information about the astronomical universe, one of the best is *The Nine Planets*. Aimed at 10-to-14-year-old readers, it is a straightforward and clear description of the sun's family of planets. Franklyn Branley is a lecturer at the American Museum-Hayden Planetarium in New York, and the inclusion of recent information in his book suggests the alertness with which a planetarium demonstrator must follow new astronomical findings.

The author keeps so closely to the planets themselves that he barely mentions the sun, satellites, and asteroids, while other minor bodies are entirely omitted. Perhaps this was required by space limitations, or the desire to simplify. But the author has missed an opportunity of giving a broad, connected picture of the solar system as an organic whole. Among those astronomical books for young readers that this reviewer has seen, this important need is filled by very few.

It is refreshing that Mr. Branley has confined himself to astronomy proper, and has given only passing reference to space travel. The rapidity of present technological progress makes it very difficult to anticipate the details of man's first successful venture into interplanetary space,

possibly still a decade or more in the future. Much of what is written today on that subject will soon be valueless. (You can find the same situation in 19th-century stories involving aviation, written before internal-combustion engines were invented; Edgar Allan Poe's *Mellona Tauta* is a good example.) Instead, *The Nine Planets* describes the solid framework of astronomical fact in which space travel will take place.

The many black-and-white illustrations by H. K. Wimmer lend attractiveness to the book, though some are merely schematic. Curiously, there is no detailed representation of Jupiter's telescopic appearance, although this would have been a most appropriate pictorial subject.

MARTHA D. ASHBROOK
Weston, Mass.

NEW BOOKS RECEIVED

PHYSICS OF METEOR FLIGHT IN THE ATMOSPHERE, *Ernst J. Opik*, 1958, *Interscience*. 174 pages. $3.85, cloth; $1.95, paper bound.

The phenomena occurring during the flight of meteors through the earth's atmosphere are here treated mathematically by one of the leading researchers in this field. This is No. 6 of the Interscience Tracts on Physics and Astronomy.

HIGH ALTITUDE AND SATELLITE ROCKETS, 1959, *Philosophical Library*. 136 pages. $15.00.

This volume contains 12 papers presented at a symposium sponsored by three British societies in July, 1957, before the first satellite launching. Among the subjects covered are rocket design, propulsion systems, reentry, high-temperature materials, telemetry and guidance, and psycho-physiological problems of flight in space. Also included are the discussions that followed the papers.

MAN'S CONQUEST OF THE STARS, *Pierre Rousseau*, 1959, *Jarrolds Publishers Ltd.*, 178-202 Great Portland St., London W. 1, England. 356 pages. 25s.

The growth of astronomy is traced from prehistoric beginnings to modern astrophysics in this fast-moving historical review. It is intended for the layman with little knowledge of astronomy. The author is a former member of the staff of Paris Observatory.

ASTRONOMY, *Theodore G. Mehlin*, 1959, *Wiley*. 392 pages. $7.95.

The broad field of astronomy is covered in this elementary college textbook. The author has not followed the traditional arrangement of topics in historical sequence, but has organized the material to emphasize modern interests. Dr. Mehlin is professor of astronomy at Williams College.

ILLUSTRATED GUIDE TO U. S. MISSILES AND ROCKETS, *Stanley Ulanoff*, 1959, *Doubleday*. 128 pages. $3.95.

For the reader desiring a general acquaintance with the missile field, this book provides illustrations, silhouettes, and brief descriptions of more than 65 American rockets and missiles.

THE RAINBOW, *Carl B. Boyer*, 1959, *Thomas Yoseloff*, 11 E. 36th St., New York 16, N. Y. 376 pages. $10.00.

This volume traces man's explanations of the rainbow from ancient mythology to modern physical optics.

THE SLEEPWALKERS, *Arthur Koestler*, 1959, *Macmillan*. 624 pages. $6.50.

A well-known novelist charts man's evolving vision of the universe from the ancient Greeks down to Newton. The struggles and contributions of Copernicus, Galileo, Tycho Brahe, and especially Johannes Kepler, are described in detail.

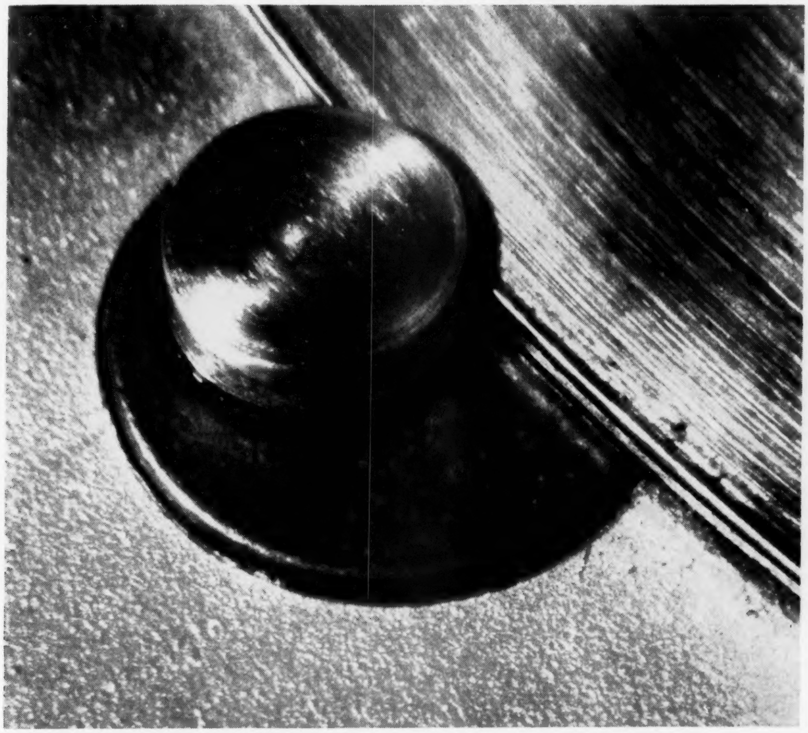
VON BREMER ASTRONOMEN UND STERNFREUNDEN, *Walter Stein*, editor, 1958, *Verlag Arthur Geist*, Bremen, West Germany. 160 pages. DM 16.80.

Bremen Astronomers and Amateurs was issued to celebrate the 200th anniversary of Wilhelm Olbers' birth (October 11, 1758) and the opening of the fine public observatory of the Olbers Society. Half of this well-illustrated volume tells about famous astronomers in the past who lived in and near Bremen, such as W. Bessel, J. H. Schröter, and F. Nölke. The remainder is an account of the Olbers Society, an active amateur group which has operated a planetarium since 1953. This organization has been very influential in spreading amateur astronomy in northern Germany.

SECOND CONFERENCE ON CO-ORDINATION OF GALACTIC RESEARCH, *A. Blaauw, G. Larsson-Leander, N. G. Roman, A. Sandage, H. F. Weaver, A. D. Thackeray*, editors, 1959, *Cambridge University Press*, New York. 93 pages. $3.00.

In this volume are presented the results of a conference held at Saltsjöbaden, Sweden, in June, 1957. Research on the Magellanic Clouds and on star clusters is stressed, and an appendix presents the recommendations of a committee formed to establish photometric standards.

QUESTAR NEWS • *July, 1959*



We would like to tell you about Questar's wonderfully smooth slow motions that have no backlash, work all the time, and constitute their own safety slipping clutches.

If you have ever used slow motions of this continuous 360° type, you will, of course, understand why we fussed around so long to get our drives exactly right. We know that nobody will continue long to use a contraption that gives more trouble than pleasure, because, being human, we prefer fun to work any old time. So if our baby is anything, it is the sweetest-working little rig you ever lent an eyeball to. Compared to some, the luxury it gives you is practically sinful, thank goodness, so you'll use it all the time.

We are not fooling about this either — some Questar owners won't give up their instruments for a single night. Such a one is Mr. C. C. Moler of 228 E. Irvin Avenue, Hagerstown, Maryland, whose letter of May 18th says: "I have written you at this length to assure you that we are highly pleased, and if you should at any time have prospects in this neighborhood we shall be glad to demonstrate our instrument." Mr. Moler's Questar reached him, alas, with one leg that did not fit at all, and to our pleas to send us back the good leg so that we could match it exactly, he just says, No, he's made the first one fit (although it's scratched) and doesn't want to miss a night. We've sent him six nonfitting legs, by guess, so far, and the matter isn't settled yet. We suppose this is what they call consumer acceptance. Anyway, it's very nice to know that our luxurious little product is considered so indispensable.

The picture was taken by a Questar through its finder, at a working distance of about 14 inches. (That's right — Questar's finder is superb for macroscopic work like this. We'll tell you more about it later.) A grainless 8-x-10 enlargement from microfile 35-mm. film in Hexacon camera body. Here is shown the 3/16-inch-diameter pinion whose tiny V-groove pinches the edges of two 4.1-inch-diameter stainless-steel disks. The large round object, smaller than your little fingernail, serves as bearing for the pinion shaft, and as spring-loaded excentric bushing to exert the necessary pressure by rotating clockwise. This view is inside the right-hand fork; on the outside the pinion shaft carries the skirted control knob. Between the stainless driven disks is a third of lesser diameter, which acts as spacer and fulcrum for the pinching squeeze exerted on the rim. This is our famous friction drive, whose velvet feel will warm the heart of any lover of fine instruments.

Simple, isn't it? Oho! That's what we thought six years ago after we had given it some 30,000 revolutions under load without a sign of wear. What a drive! No backlash or dust-jamming or loosening, as with gears. But like many simple things, our fine drive had strict requirements. If the pinion's temper is too soft, it quickly wears. If heat-treated to too great a Rockwell number, it will fracture from excessive brittleness. The size and angle of the pulley notch is very critical, to match the total thickness of three disks of stainless steel. So these must be held to plus or minus two ten-thousandths of an inch. The hardness or temper of these disks is also very critical, so here is what we do: We buy standard warehouse, full-hard-temper 18-8, type-302 stainless-steel strip of a certain greater thickness, then send it to a company in New England which has a little micro-rolling mill. Its rolls are only 4.5 inches wide, just big enough, and after a few passes our steel has just the right degree of thickness and extra hard spring. An accurately ground $800 die is used to turn this very tough thin ribbon into perforated circles, one-third of which get turned down on the engine lathe. Not so critical is the excentric bushing, which works best when made of marine bronze, with a brass arm silver-soldered to it. Lubrication is with "Molycote."

Finally, both outside disks are hand-deburred, and polished on the engine lathe until they look the way we want them to. Then, upon assembly, each drive is "broken in" until it works and feels just right. At this writing some 300 pinions are being heat-treated first and having their V-grooves ground later, a method which costs more but may produce a finer piece. Slipping clutches in both side-arms and base use the "stickage" property of a thin sheet of nylon to resist first gross movement before sliding easily. This may keep you "on target" during an accidental jar, a useful feature quite unfelt when knobs are turned.

Yes, this is going to a lot of trouble to perfect just part of our machine. We tried an awfully large number of materials, and scrapped pieces of metal by the thousand, before we learned what not to do. It cost us a king's ransom when pennies were in short supply, but we have never for a minute had regrets. Because this drive is just the thing our Questar needed, and we can just about guarantee it will spoil you for any other kind.

Questar will be on exhibition in "20th Century Design: U.S.A." at the Cleveland Museum of Art, July 8 to August 16, 1959, and the City Art Museum of St. Louis, September 14 to October 25, 1959.

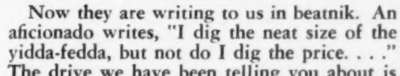
Export and Import Department: A Questar has for some time been used in solar I.G.Y. work by Dr. Huberta von Bronsart in Stuttgart. Last week we shipped one to Prof. K. O. Kiepenheuer of the Fraunhofer Institute at Freiburg, Germany.

The only parts of Questar we import are the leather case from England, and our special focusing eyepieces and one prism from Japan. We have now exported Questars to every continent.

Now they are writing to us in beatnik. An aficionado writes, "I dig the neat size of the yidda-fedda, but not do I dig the price. . . ." The drive we have been telling you about is just one small part of the cost.

Questar's $995 price has been the same since 1955. We have been trying to hold the price line by more sales and more efficient manufacture, while continuing to build into each instrument better components made by more expensive processes. To build our business we have been satisfied with modest profits, which have never been large enough to pay commissions to distributors. Others have found that even easy-to-make types of catadioptric telescopes cannot be made at bargain prices. So far so good — we hope to hold the line a little longer against this thing of one and two price rises every year on some materials. We can tell you this, that we will never cut the quality, and future Questars will never cost less than they do right now. What brought on these thoughts was the shock we received upon learning that the cost of one part had jumped 50 per cent in three years.

QUESTAR CORPORATION
New Hope, Pennsylvania



GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

A Low-Cost Furnace To Melt Metal for Castings — II

CONSTRUCTION of a burner will complete the reverberatory furnace described here last month. This burner, shown in Fig. 8, is designed to operate on oil, bottled gas, or low-pressure natural gas. It may not, however, work well on all three fuels with a furnace of some other design.

Pipe-Fitting Parts. The burner is constructed mostly from pipe-fitting parts readily obtained at any plumbing supply house. A $1\frac{1}{2}$" pipe tee and two cast-iron plugs are needed, and only the plugs require machining. In Fig. 9 the plug at the right is bored with a $\frac{3}{4}$" horizontal hole and then drilled and tapped for a setscrew. The plug at the left is the Venturi, and the dimensions given (for natural gas in Fig. 9, for oil or bottled gas in Fig. 10) must be carefully followed, and the unit must be polished so that the inside surface is perfectly smooth.

The Jet. The burner jet is brass, aluminum, or steel, and can be moved in and out of the tee by loosening the setscrew. This regulates the flame, and the optimum position varies depending on the fuel used, fuel pressure, and air flow produced by the blower. Tightening the setscrew holds the jet in place once the best position is determined.

Fig. 9 shows the arrangement for natural gas; here the air enters through the jet and the fuel from below. This is reversed if oil or bottled gas is used, and a special jet (shown in Fig. 11) must be used. For natural gas you will need a standard $1\frac{1}{2}$" plug-type shutoff valve at the base of the tee to regulate the gas flow; another valve is required on the air jet. This is also a plug-type shutoff, and must be $\frac{1}{2}$" inside thread, bushed down to $\frac{3}{8}$".

For oil or bottled gas, a needle-type valve is needed on the jet to control the fuel flow, the air pressure being regulated by a rheostat on the blower.

The Blower. No matter what type of fuel is used, a blower is essential to supply air under pressure. Although professional foundrymen use complex units, a simple one can be made at little expense. The blower shown in Fig. 8 cost only $7.85 and is adequate for this furnace. The unit and its motor were purchased from a vacuum-cleaner repair shop for $2.75; the rheostat, from a sewing-machine agency, cost $3.00; and a cord and plug took up the balance. When you buy a blower, make sure that the motor has ball bearings and that the brushes and commutator are in good condition. Mount

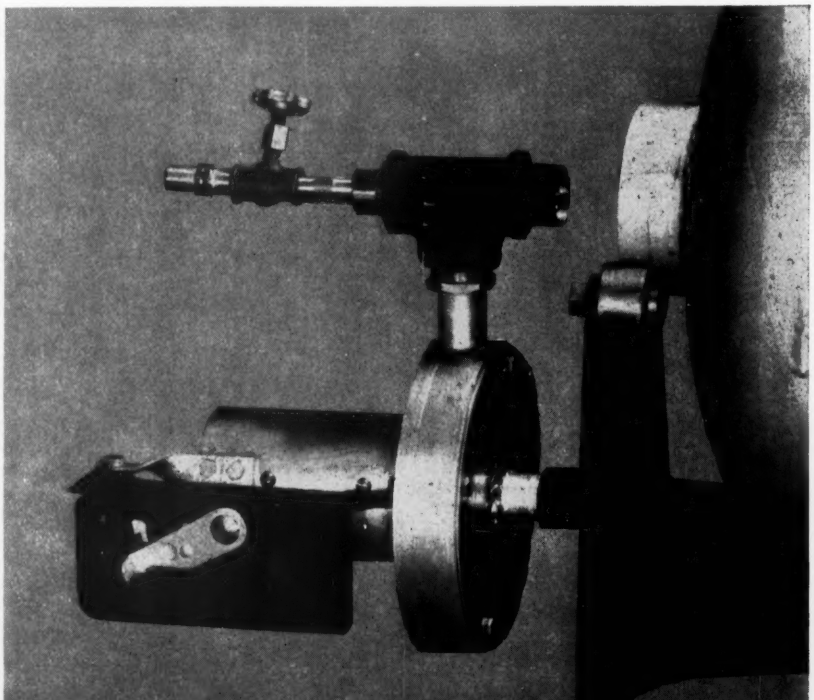


Fig. 8. The burner for the furnace. Flame issues from the Venturi plug on top of the blower unit and enters the furnace through the port at the right.

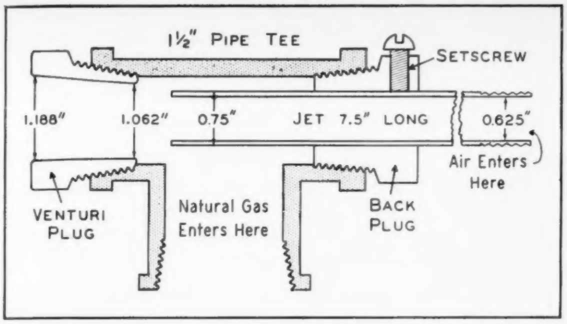


Fig. 9. For natural gas the jet of the burner is a straight tube feeding directly into the Venturi. When used for this type of fuel, the blower is put behind the jet and not at the bottom of the tee as in Fig. 8. The dimensions given here and in Fig. 10 should be carefully followed if these jets are to perform well.

the unit so that the air intake cools the motor by drawing air around it.

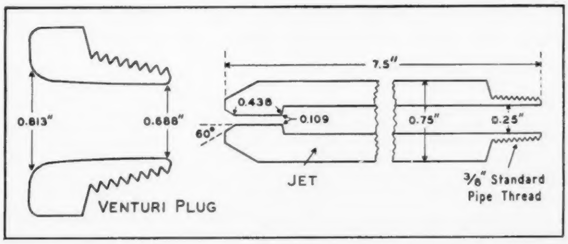
In Fig. 8 the blower is located at the bottom of the pipe tee for use with the jet for oil or bottled gas. Oil should be fed under slight pressure, by piping it from a vented tank about 4′ above and to one side of the furnace. Bottled gas is already under pressure.

Natural gas is generally supplied at very low pressure. To combine it with air and force the mixture into the furnace, the blower is connected to the jet and the gas to the bottom of the tee. As the air stream flows through the Venturi, a partial vacuum is created in the burner housing, and this draws the gas upward into the tee and causes it to mix with the air.

Charging the Furnace. As brass and aluminum are the metals most often used by amateurs who make their own castings, the charging procedures for them are described here. While we assume that the furnace is oil-fired, the technique for the other fuels is practically the same. It is best to use brass for the first heat, because the higher melting point for this metal will insure a thorough burning-in of the lining.

Connect a line from a vented 5-gallon fuel-oil can, suspended 4′ above the furnace, to the valve at the rear of the jet. With the charge-pour opening almost upright, place a mound of hot embers in the tank. Start the blower at about one-third speed and very slowly open the oil valve until an orange flame about a foot long emanates from the Venturi opening. When the lining heats to a light red, allow more oil followed by more air, until the lining glows light yellow. The flame from the blower is now short and yellowish white. Begin loading the tank by dropping 10 to 15 pounds of brass chunks into the charge-pour opening. When these are melted, add the rest of the metal. After all the brass has become fluid, the first casting may be poured.

Fig. 10. With oil or bottled gas the jet has a constriction at its throat and the air is fed from the bottom of the unit.



For melting aluminum, the process is similar. Heat the furnace as before and then temper the flame by slowing the blower and increasing the flow of oil. This has the dual purpose of reducing the heat to a suitable level for aluminum and of preventing the oxidation of the metal by excess air. The furnace should now be ready to receive the charge of aluminum.

Casting. The correct pouring temperature is most easily determined with a

Fig. 11. The principal jet parts for a burner for oil or bottled gas. The Venturi is at top center in the picture, the back plug at the right. The flat section of the jet is a seat for the setscrew; it prevents the unit from turning when the screw is loosened for adjusting the jet.

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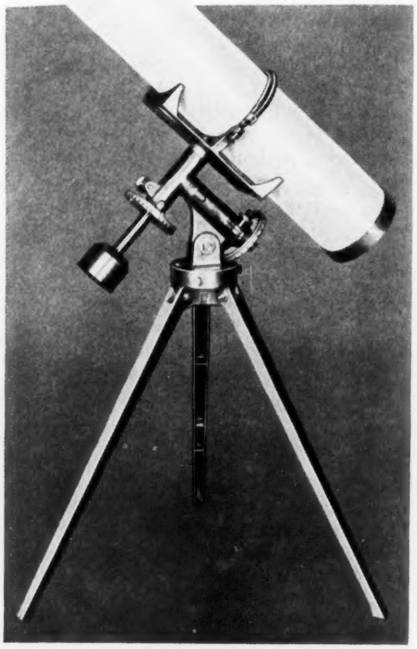

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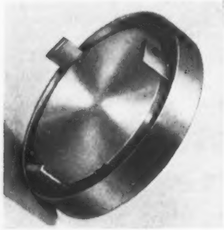

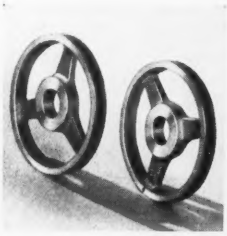

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Complete for tubes to 9" x 60"	89.75	"
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pyrometer. If such an instrument is not available, the following test is sufficiently accurate and is easily performed with a little care. When the metal shows a faint red glow in subdued light, take a clean steel rod ¼" in diameter (a welding rod is just right) and stir the molten metal for 10 seconds. Quickly withdraw the rod, and if the metal slips away from the rod cleanly it is ready for pouring. Before casting, take a second welding rod having 2" of one end bent at a right angle and skim the surface of the molten metal to remove dross.

At the end of a casting period, drain the furnace by rotating it until the opening faces downward, and allow it to cool in this position. Always start with a clean and empty tank, as any metal left to burn during the heating-up period can damage the lining. Furthermore, starting with an empty tank, instead of one partially filled, takes about half as much time to bring the metal to pouring temperature.

Fig. 13. Castings made with a furnace like the one described in this article.

Fig. 12. Mold for a telescope yoke.

Molds. For most telescope parts that have a ring or cylindrical shape and not too large a diameter, suitable molds can be made from tin cans. Printed or painted labels should be burned off by heating the cans red hot. Be sure they are clean and dry before making a pouring. Any water left in the cans to be used as molds is likely to cause blowholes in the casting.

The pouring port and the mold should be as close together as possible to minimize oxidation of the metal as it passes through the air. Therefore, before starting a charge, place the mold so that when the furnace is rotated to pouring position the opening just clears the mold. It may be necessary to raise the mold by putting bricks beneath it.

A telescope mounting yoke was cast in the mold made from two tin cans illustrated in Fig. 12. Two thin-walled conduit bosses were brazed to the outer can 180° apart. The inner one was filled with gravel to keep it from floating, and was carefully centered before pouring began.

The finished mounting yoke, still in its

Fig. 14. The finished tube yoke machined from the casting made with the mold in Fig. 12.

mold, is shown in Fig. 13, flanked with two other castings. The gravel has been dumped to speed cooling. At the left is a casting of a sleeve for holding an objective lens. The outer can has been removed with a pair of diagonal cutting shears, while the inner is shown during removal. A ring casting for mounting an objective is at the right. The machined yoke, ready to receive the telescope tube, is pictured in Fig. 14. Note the fine texture of the metal. The fork for the yoke (Fig. 15) was constructed with $1\frac{1}{2}''$ thin-wall conduit forming the mold.

The aluminum used for all these castings was scrap corrugated roofing, a material which most scrap dealers are glad to sell for a few cents per pound. When using scrap aluminum, it is a good idea to sprinkle about half a teaspoon of aluminum welding flux over the molten metal just before pouring.

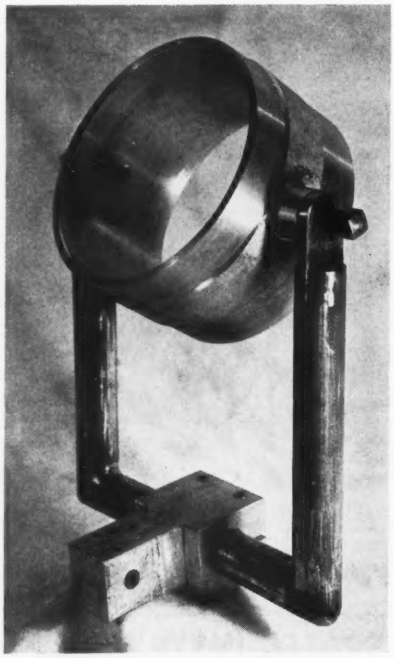

Fig. 15. Assembled yoke and fork.

Precautions. Amateurs should experience no difficulty in building the furnace and making the castings, provided they proceed methodically and carefully.

The use of wooden planks or heavy steel plates as platforms on which to set molds that have just received pourings is not recommended. Wooden planks will char and smoke up the workshop. The coldness of steel plates will produce defective castings by cooling the metal too quickly. Bricks are safe and insulate the mold. Take care not to jar or move the mold until the pouring has cooled enough for its surface to retain its shape. The mold can be moved when the metal will not char a piece of dry paper.

A carelessly constructed or operated furnace can be a definite fire hazard. All precautions must be taken to prevent the unit from tipping and spilling molten metal on the operator or the floor.

Other articles on making furnaces and castings can be found in *Amateur Telescope Making — Book II* and *Book III*, and in *Procedures in Experimental Physics*, by John Strong. The cope-and-drag method was described in this department in July and August, 1952. The author will be glad to answer letters requesting further information if stamped, self-addressed envelopes are included.

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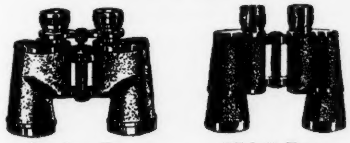

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7 x 35	578	American Wide-Angle 11°	**35.00**	—
7 x 50	372	"Zeiss"	**24.95**	**22.50**
7 x 50	372	American	**32.50**	—
8 x 30	393	"Zeiss"	**21.00**	**18.25**
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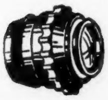

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Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm. (2⅛")	254 mm. (10")	**$12.50**	83 mm. (3¼")	660 mm. (26")	**$28.00**
54 mm. (2⅛")	300 mm. (11.8")	**12.50**	83 mm. (3¼")	711 mm. (28")	**28.00**
54 mm. (2⅛")	330 mm. (13")	**12.50**	83 mm. (3¼")	762 mm. (30")	**28.00**
54 mm. (2⅛")	390 mm. (15.4")	**9.75**	83 mm. (3¼")	876 mm. (34½")	**28.00**
54 mm. (2⅛")	508 mm. (20")	**12.50**	83 mm. (3¼")	1016 mm. (40")	**30.00**
54 mm. (2⅛")	600 mm. (23½")	**12.50**	102 mm. (4")	876 mm. (34½")	**60.00**
54 mm. (2⅛")	762 mm. (30")	**12.50**	108 mm. (4¼")	914 mm. (36")	**60.00**
54 mm. (2⅛")	1016 mm. (40")	**12.50**	110 mm. (4⅜")*	1069 mm. (42-1/16")	**60.00**
54 mm. (2⅛")	1270 mm. (50")	**12.50**	110 mm. (4⅜")	1069 mm. (42-1/16")	**67.00**
78 mm. (3-1/16")	381 mm. (15")	**21.00**	128 mm. (5-1/16")*	628 mm. (24¾")	**75.00**
80 mm. (3⅛")	495 mm. (19½")	**28.00**	128 mm. (5-1/16")	628 mm. (24¾")	**85.00**
81 mm. (3-3/16")	622 mm. (24½")	**22.50**	*Not coated		

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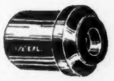

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Pyrex	6"	60"	**25.00**

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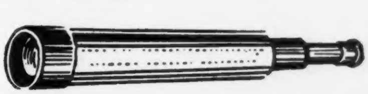

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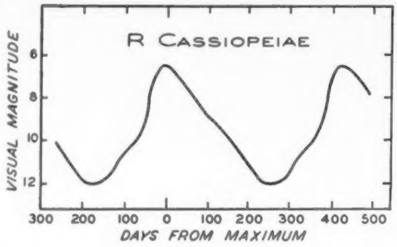
SKY - GAZERS EXCHANGE

CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

R CASSIOPEIAE

THE long-period variable star R Cassiopeiae reaches greatest brightness late this July, when it will be visible in binoculars and possibly to the unaided eye. At the maximum of its 431-day cycle, R Cas has been recorded as bright as magnitude 4.8 and as faint as 8.5. Similarly, the minimum magnitude can be anything between 10.4 and 13.6. Thus, the accompanying light curve, reproduced from



Leon Campbell's *Studies of Long Period Variables*, shows only the average behavior of this star, as deduced from about one thousand amateur observations. Records of its light variations go back to 1850.

R Cas is a triple star. There is an 11.4-magnitude companion about 30" distant in position angle 330°, easily detected in small telescopes. Much more difficult is the closer, 14½-magnitude companion first seen by T. E. Espin in 1899. All observers have commented on the very red color of the variable star itself, which is situated at right ascension 23^h $55^m.8$, declination +51° 07′ (1950 co-ordinates), about seven degrees southwest of Beta Cassiopeiae.

VARIABLE STAR MAXIMA

July 2, R Caeli, 043738, 8.0; 2, V Ophiuchi, 162112, 7.5; 5, R Pegasi, 230110, 7.9; 16, SS Virginis, 122001, 6.9; 23, R Cassiopeiae, 235350, 6.5; 26, R Aurigae, 050953, 7.8; 29, RR Sagittarii, 194929, 6.6.

August 2, RT Cygni, 194048, 7.4; 7, S Herculis, 164715, 7.6.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

JULY METEORS

The moon, just past last quarter, should not interfere with observations of the Delta Aquarid meteor shower. A single observer may see about 20 meteors per hour on July 29th at the peak of this 20-day shower. At maximum, the meteors appear to radiate from a point just west of Delta Aquarii, at right ascension 22^h 36^m, declination −17°. The radiant moves to the east and slightly north at a rate of almost 1° per day. W. H. G.

MINOR PLANET PREDICTIONS

Psyche, 16, 9.3. July 11, 20:56.9 −15-04; 21, 20:50.1 −15-38; 31, 20:42.2 −16-19. August 10, 20:33.9 −17-02; 20, 20:26.4 −17-42; 30, 20:20.5 −18-15. Opposition on August 1.

Laetitia, 39, 9.1. July 11, 21:02.7 −7-48; 21, 20:56.6 −8-36; 31, 20:49.1 −9-38. August 10, 20:41.1 −10-51; 20, 20:33.8 −12-07; 30, 20:28.0 −13-23. Opposition on August 2.

Baucis, 172, 9.6. July 21, 21:48.6 −20-38; 31, 21:39.6 −20-31. August 10, 21:28.8 −20-19; 20, 21:17.7 −20-00; 30, 21:07.8 −19-29. September 9, 21:00.4 −18-47. Opposition on August 12.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

July 3, 7:10; 6, 3:58; 9, 0:47; 11, 21:36; 14, 18:24; 17, 15:13; 20, 12:02; 23, 8:50; 26, 5:39; 29, 2:27; 31, 23:16.

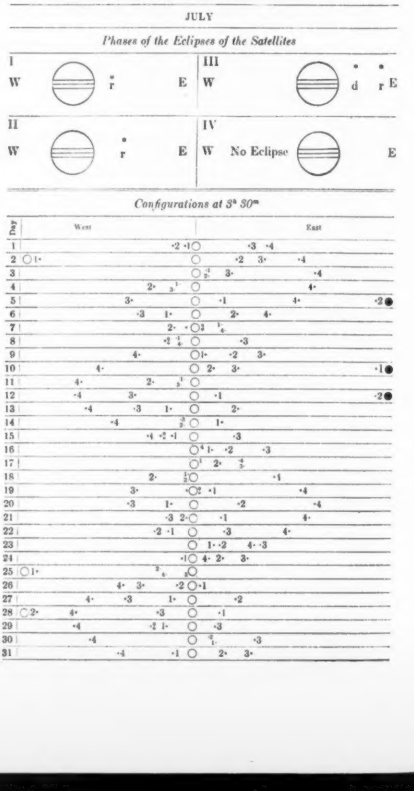
August 3, 20:04; 6, 16:53; 9, 13:42.

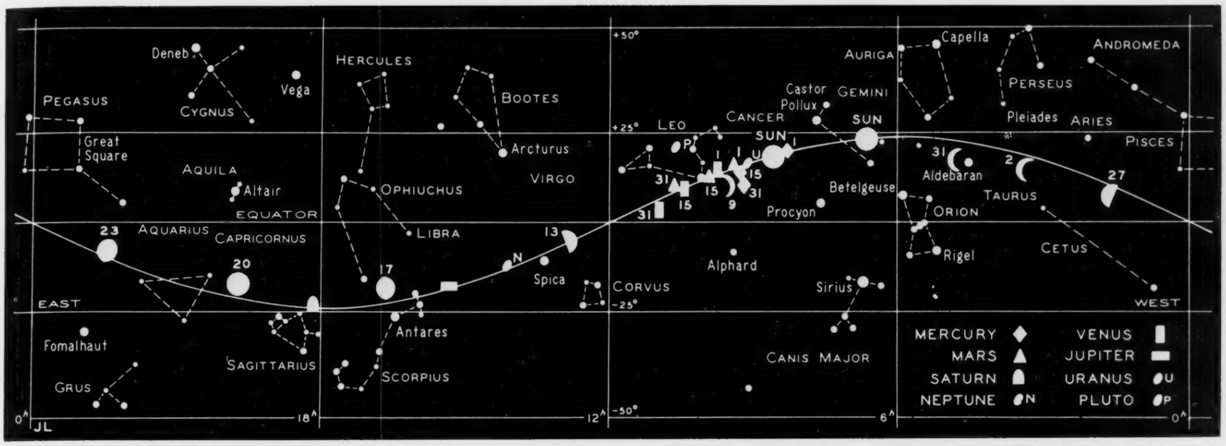
These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from *The American Ephemeris and Nautical Almanac*.





THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0^h Universal time on the respective dates.

Mercury reaches greatest elongation on July 8th, 26° 14′ east of the sun. At this time it is magnitude +0.7, and can be seen in the west, setting about 1½ hours after the sun.

Venus is a brilliant object in the western sky all month, setting about two hours after sunset on the 15th. Greatest brilliancy occurs on the 26th, at which time the planet's magnitude is −4.2. A telescope will show the disk to be a beautiful crescent, 27-per-cent illuminated and 37″.4 in diameter. The moon will be close to Venus on the evening of the 9th, passing about 3° south.

On July 7th, Venus will occult Regulus for observers in southern Asia, Africa, Europe, South America, and eastern North America. For the last, Venus will be low in the east in full daylight at the time of the occultation. Details were given on page 474 last month; see also page 483 of this issue.

Mars is a 2nd-magnitude object near Regulus at midmonth, low in the west at sunset. The planet is poorly placed for observation all month. The moon is to pass 5° south of Mars on the evening of July 8-9.

Jupiter is in Libra and quite bright — magnitude −1.9 on the 15th. This giant planet crosses the meridian at sunset and sets about half an hour after midnight, local time. Telescopically, the planet's slightly flattened disk is seen to have an equatorial diameter of 41″ and a polar one 3″ less. Jupiter is stationary in right ascension on July 20th, then resumes eastward motion among the stars. On the morning of the 15th the moon will pass about 3° north of the planet.

Saturn at midmonth is low in the southeast at sunset, appearing as an object of magnitude +0.3 in Sagittarius and visible most of the night. In a telescope, the planet's disk is 16″.4 in polar diameter, and the ring system 41″.2 in extent. The moon will pass 4° north of Saturn in the early morning of July 18th.

Uranus is in Cancer, too close to the sun to be easily seen this month.

Neptune is stationary in right ascension on July 17th, when it resumes direct (eastward) motion among the stars. Eastern quadrature is reached on the 28th, when the planet crosses the meridian about an hour before sunset and is visible in the southwest during the evening. This 8th-magnitude object is in Virgo, and on July 28th will be at right ascension $14^h\ 10^m.8$, declination −11° 13′ (1950 co-ordinates), readily visible in binoculars and small telescopes. See the map of Neptune's path, on page 173 of the January issue.

W. H. G.

MOON PHASES AND DISTANCE

New moon	July 6, 2:00
First quarter	July 13, 12:01
Full moon	July 20, 3:33
Last quarter	July 27, 14:22
New moon	August 4, 14:34

	July	Distance	Diameter
Apogee	1, 19^h	252,000 mi.	29′ 28″
Perigee	17, 14^h	226,200 mi.	32′ 49″
Apogee	29, 12^h	251,400 mi.	29′ 32″
	August		
Perigee	13, 16^h	229,200 mi.	32′ 24″

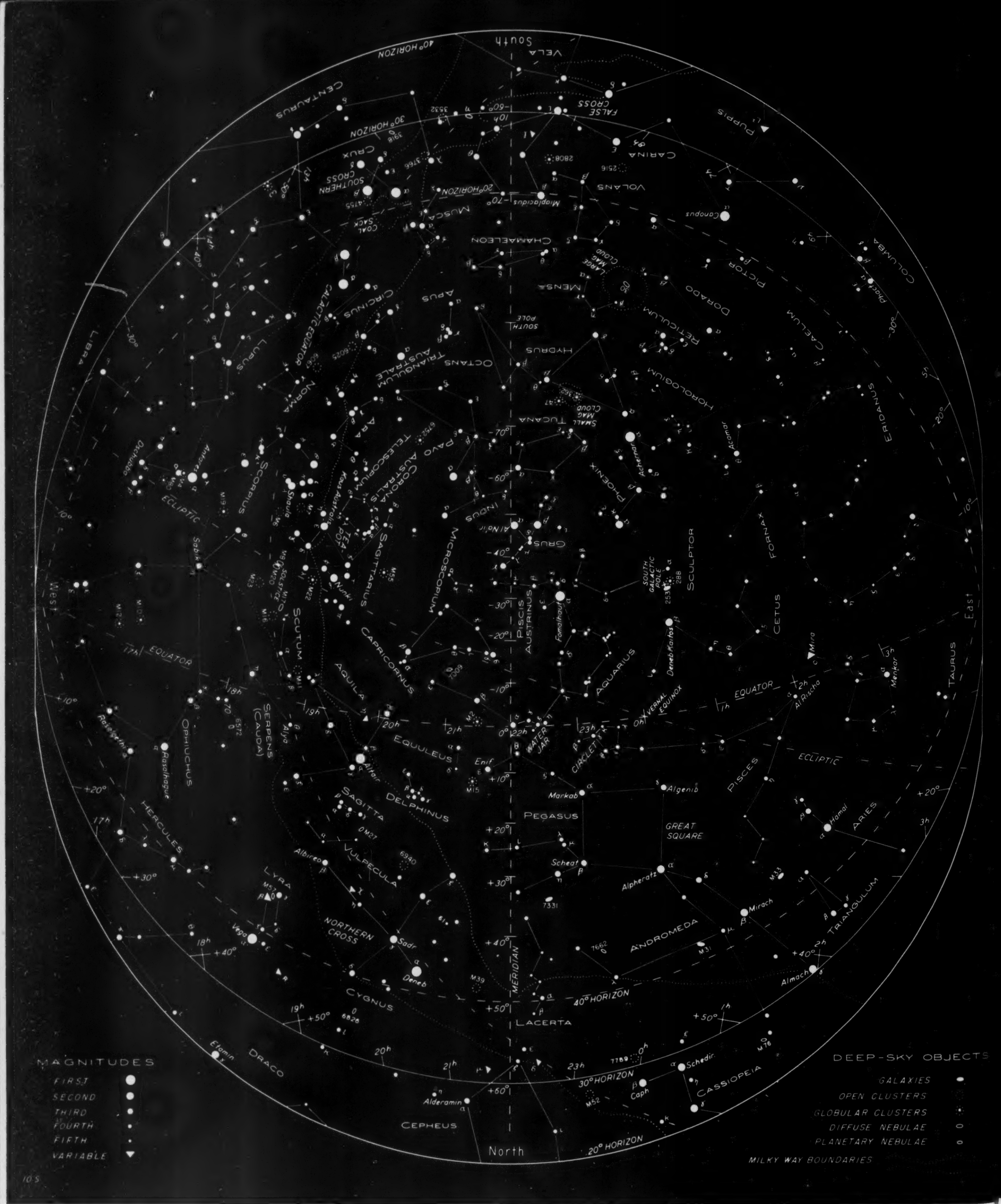
OCCULTATION PREDICTIONS

July 15-16 **Theta Librae** 4.3, 15:51.5 −16-36.6, 10. Im: **F** 6:10.9 −0.9 +1.2 41.

See page 474 of last month's issue for explanation and the rules for determining the times at various localities.

UNIVERSAL TIME (UT)

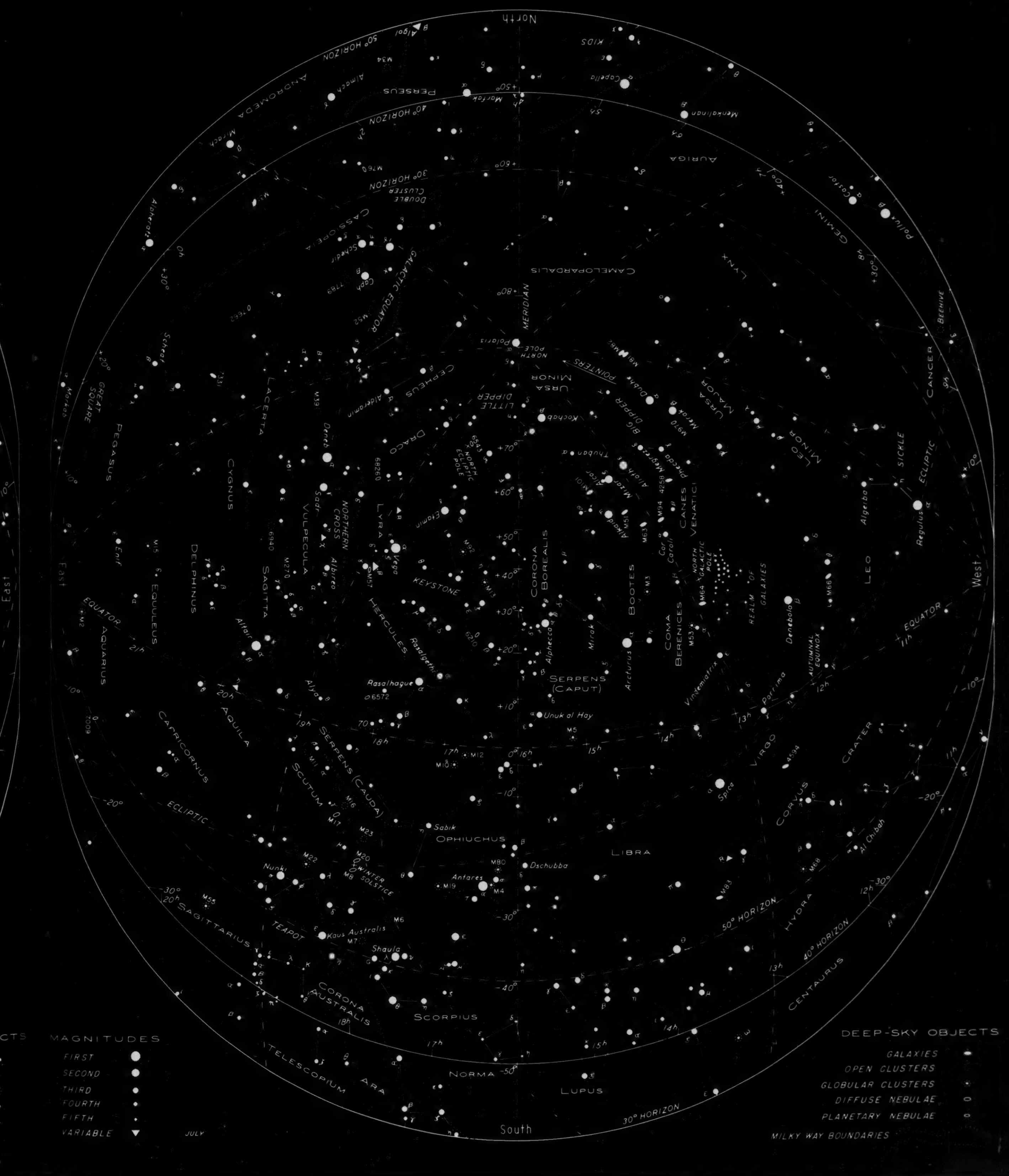
TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.



SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 22nd of September, respectively; also, at 9 p.m. and 8 p.m. on October 7th and 22nd. For other dates, add or subtract ½ hour per week.

South of the zenith are four birds first listed as constellations by Johann Bayer in his "Uranometria" of 1603. They are Grus the Crane, Pavo the Peacock, Tucana the Toucan, and Phoenix, a mythical bird which, since ancient times, has been a symbol of the resurgence of life.



STARS FOR JULY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 8th and 23rd of July, respectively; also, at 7 p.m. on August 7th. For other dates, add or subtract ½ hour per week.

Corona Borealis, the Northern Crown, and sprawling Hercules are now high in the northern sky. Look for the bright globular cluster M13 in the side of Hercules' keystone; it is just visible to the unaided eye. Farther north, Draco the Dragon winds across the polar heavens.

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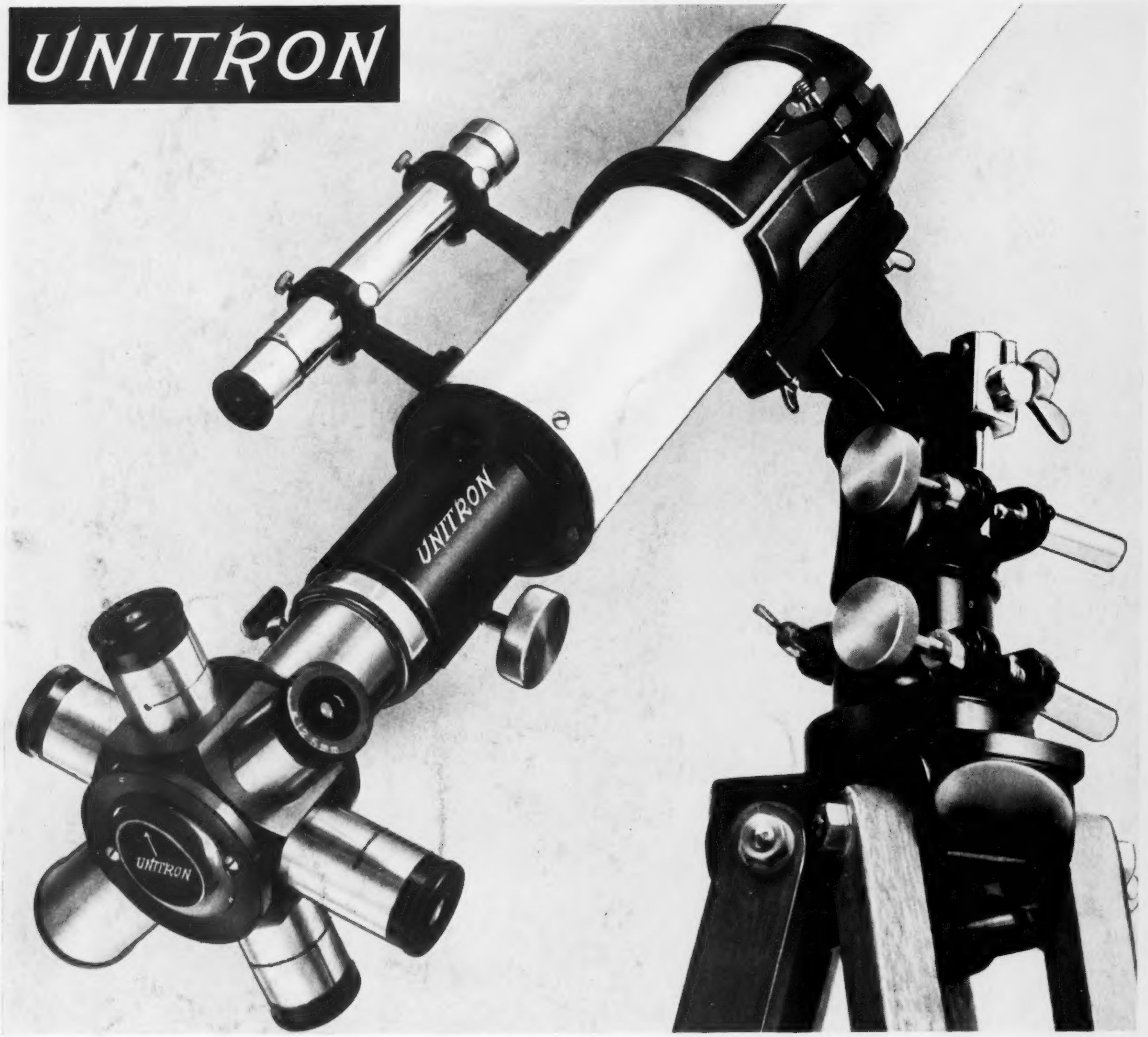

See pages 532 and 533.